Twenty-third Annual Report

of the

NEW JERSEY STATE

Agricultural Experiment Station

and the

FIFTEENTH ANNUAL REPORT

of the

New Jersey Agricultural College Experiment Station

for the year ending

October 31st, 1902.

35282

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To His Excellency Franklin Murphy, Governor of the State of New Jersey:

SIR—I have the honor to submit herewith the Twenty-third Annual Report of the New Jersey State Agricultural Experiment Station, as required by the law establishing the Station, which was approved March 10th, 1880, and which is chapter CVI. of the laws of that year.

DAVID D. DENISE,
President.

NEW BRUNSWICK, N. J., November 29th, 1902.

To His Excellency Franklin Murphy, Governor of the State of New Jersey:

SIR—In compliance with an act of Congress, approved March 2d, 1887, and with an act of the Legislature of this State, approved March 5th, 1888, I beg leave to submit, on behalf of the Trustees of Rutgers College in New Jersey maintaining Rutgers Scientific School, the New Jersey State College for the benefit of Agriculture and Mechanic Arts, the Fifteenth Annual Report of the operations of that department of the College which has been organized in accordance with said act of Congress, and is known as "The State Agricultural College Experiment Station."

AUSTIN SCOTT,
President.

NEW BRUNSWICK, N. J., November 29th, 1902.

NEW JERSEY AGRICULTURAL EXPERIMENT STATIONS,

NEW BRUNSWICK, N. J.

1. STATE STATION. ESTABLISHED 1880.

BOARD OF MANAGERS.

HIS EXCELLENCY FRANKLIN MURPHY, . . Trenton, Governor of the State of New Jersey.
AUSTIN SCOTT, PH.D., LL.D., . . New Brunswick, President of the State Agricultural College.
EDWARD B. VOORHEES, Sc.D., . Professor of Agriculture of the State Agricultural College.

FIRST CONGRESSIONAL DISTRICT.

EPHRAIM T. GILL, . . . Haddonfield.
ROBERT GWYNNE, JR., . Salem.

SECOND CONGRESSIONAL DISTRICT.

WINFIELD S. BONHAM, . . Shiloh.
JOHN E. DARNELL, . . Masonville.

THIRD CONGRESSIONAL DISTRICT.

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JAMES NEILSON, . . . New Brunswick.

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GEORGE FRITTS, ... Pattenburg.

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JOSIAH KETCHAM, . . . Belvidere.
JAMES A. BURNETT, . . . Hilton.

SIXTH CONGRESSIONAL DISTRICT.

ABRAM C. HOLDRUM, . . Westwood.
GEORGE H. BLAKELEY, . Paterson.

SEVENTH CONGRESSIONAL DISTRICT.

GEORGE E. DE CAMP, . . . Roseland.
CYRUS B. CRANE, . . . Caldwell.

EIGHTH CONGRESSIONAL DISTRICT.

GEORGE DOBBS, ... East Orange.
IRA C. KILBURN, . . . South Orange.

NINTH CONGRESSIONAL DISTRICT.

RYNIER J. WORTENDYKE, . Jersey City.
LUCIUS F. DONOHOE, M.D., . Bayonne.

TENTH CONGRESSIONAL DISTRICT.

JOHN B. WILLIAMS, . . . New Durham.
PHILIP M. BRETT, . . . Jersey City.

STAFF.

EDWARD B. VOORHEES, Sc.D., . . Director.
IRVING S. UPSON, A.M., . . . Chief Clerk; Secretary and Treasurer.
MARY A. WHITAKER, ... Stenographer and Typewriter.

LOUIS A. VOORHEES, A.M., Chief Chemist.
JOHN P. STREET, M.Sc., Associate Chemist.
WILLIAM P. ALLEN, B.Sc., Assistant Chemist.
VINCENT J. CARBERRY, Laboratory Assistant.
JOHN B. SMITH, Sc.D., Entomologist.
ALVA T. JORDAN, B.Sc., Assistant in Horticulture.
CLARENCE B. LANE, B.Sc., Assistant in Dairy Husbandry.
JACOB G. LIPMAN, A.M., Soil Chemist and Bacteriologist.

HARRY W. WILLIAMS, . . . Janitor.

2. AGRICULTURAL COLLEGE STATION. ESTABLISHED 1888.

BOARD OF CONTROL.

The Board of Trustees of Rutgers College in New Jersey.

EXECUTIVE COMMITTEE OF THE BOARD.

AUSTIN SCOTT, PH.D., LL.D., President of Rutgers College, Chairman, . . New Brunswick.
HON. HENRY W. BOOKSTAVER, LL.D., ... 24 East 64th Street, New York City.
JAMES NEILSON, ... New Brunswick.
PAUL COOK, ... Troy, New York.
WILLIAM H. LEUPP., ... New Brunswick.
JOHN W. HERBERT, JR., ... Helmetta.

STAFF.

EDWARD B. VOORHEES, Sc.D., ... Director.
JULIUS NELSON, PH.D., ... Biologist.
BYRON D. HALSTED Sc.D., ... Botanist and Horticulturist.
JOHN B. SMITH, Sc.D., ... Entomologist.
JAMES A. KELSEY, M.Sc., ... Field Assistant.
IRVING S. UPSON, A.M., ... Disbursing Clerk and Librarian.
AUGUSTA E. MESKE, ... Stenographer and Typewriter.

THE COLLEGE FARM.

The Trustees of the College give the Stations the use of seven acres of land for experiments in Horticulture and Botany, and the remainder of the farm (90 acres), well stocked and equipped, for experiments in Dairying. The income from the dairy pays for the labor and maintenance of the farm, and in part for dairy experiments.

TREASURER'S REPORT.

Irving S. Upson, in account with the New Jersey State Agricultural Experiment Station, November 1st, 1901, to October 31st, 1902.

APPROPRIATION FOR SALARIES AND EXPENSES.

RECEIPTS.

From State Treasurer	$15,000 00

PAYMENTS.

Salaries and pay of Chemists and Assistants	$10,629 12
Expenses of the Board of Managers	55 15
Stationery	242 27
Printing	172 38
Postage	122 98
Furniture	2 00
Fuel	192 54
Gas, Electricity and Water	228 78
Laboratory Expenses	965 31
Field and Feeding Experiment Expenses	1,013 14
Freight, Express and Cartage	76 50
Expenses Collecting Samples of Fertilizers	327 63
Traveling Expenses	115 69
General Fittings, Repairs and Improvements	727 18
Insurance	23 00
Reference Books	91 24
Contingent Expenses	15 00
	$15,000 00

APPROPRIATION FOR CARRYING OUT THE PROVISIONS OF "AN ACT CONCERNING THE REGULATION OF THE SALE OF CONCENTRATED COMMERCIAL FEEDING STUFFS."

RECEIPTS.

From State Treasurer	$3,000 00

PAYMENTS.

Salaries and pay of Chemists and Assistants	$2,172 27
Postage	1 05
Laboratory Fittings, Apparatus and Supplies	671 67
Expenses Collecting Samples of Feeding Stuffs	155 01
	$3,000 00

APPROPRIATION FOR PRINTING BULLETINS.

RECEIPTS.

From State Treasurer	$1,000 00

PAYMENTS.

For Printing Bulletins	$1,000 00

SPECIAL ALLOWANCE BY THE GOVERNOR FROM EMERGENCY APPROPRIATION FOR CARRYING OUT THE PROVISIONS OF "AN ACT TO PROVIDE FOR AN INVESTIGATION AND REPORT UPON THE MOSQUITO PROBLEM, IN ITS RELATION TO THE SANITARY, AGRICULTURAL AND OTHER INTERESTS OF THE STATE."

RECEIPTS.

From State Treasurer	$1,000 00

PAYMENTS.

Compensation of Assistants	$625 00
Labor	42 40
Postage	30 00
Laboratory and Incidental Supplies	52 76
Freight and Express	4 26
Traveling Expenses	222 18
Reference Books and Papers	23 40
	$1,000 00

The Auditing Committee of the Experiment Station has examined the accounts of the Treasurer of said Station, and has found them correct.

JOHN E. DARNELL,
GEORGE E. DE CAMP,
Auditing Committee.

NEW BRUNSWICK, N. J., January 16th, 1903.

FINANCIAL STATEMENT.

THE TRUSTEES OF RUTGERS COLLEGE

FOR

THE NEW JERSEY STATE AGRICULTURAL COLLEGE EXPERIMENT STATION

IN ACCOUNT WITH

THE UNITED STATES APPROPRIATION, 1901–1902.

To receipts from the Treasurer of the United States as per appropriation for fiscal year ending June 30th, 1902, as per act of Congress approved March 2d, 1887		$15,000 00
By Salaries	$9,580 00	
Labor	953 51	
Publications	1,506 93	
Postage and Stationery	268 68	
Freight and Express	82 61	
Heat, Light and Water	279 15	
Chemical Supplies	56 37	
Seeds, Plants and Sundry Supplies	160 90	
Fertilizers	156 41	
Feeding Stuffs	154 62	
Library	620 13	
Tools, Implements and Machinery	104 00	
Furniture and Fixtures	228 94	
Scientific Apparatus	204 22	
Live Stock	....	
Traveling Expenses	383 66	
Contingent Expenses	171 20	
Building and Repairs	88 67	
Total		$15,000 00

We, the undersigned duly appointed auditors of the corporation, do hereby certify that we have examined the books and accounts of the New Jersey State Agricultural College Experiment Station for the fiscal year ending June 30th, 1902, that we have found the same well kept and classified as above, and that the receipts for the year from the Treasurer of the United States are shown to have been $15,000, and the corresponding disbursements $15,000, for all of which proper vouchers are on file, and have been by us examined and found correct, thus leaving no unexpended balance.

And we further certify that the expenditures have been solely for the purpose set forth in the act of Congress approved March 2d, 1887.

Signed, AUSTIN SCOTT,
EDWARD B. VOORHEES,
Auditors.

REPORT OF THE DIRECTOR.

REPORT OF THE DIRECTOR.

The laws, both State and national, which provide for Agricultural Experiment Stations, have for their purpose the establishment of institutions which shall serve the public mainly in the following directions :

First, to protect the farmer in the purchase of commercial fertilizers, concentrated feeds, and other materials, whose composition and value cannot be readily discerned by visual inspection ; second, to give the farmer such information as science may offer in reference to the purchase and economical use of these materials ; and third, to conduct such scientific investigations of soils, crops, animals, insects, plant diseases, etc., as may result in the establishment of new facts and principles, which may not only be of service in the farming and related industries, but also add to the sum of our knowledge. The value of the results of the work of Agricultural Experiment Stations may therefore be regarded as both direct, or immediately useful to a special class, and indirect, or useful to the entire community, because of the dependence of all classes upon agriculture, the basic industry.

Since the staff of scientific workers of the State Station are more completely occupied with the work of inspection, the results obtained there have been of more immediate value to the farming public than those of the College Station, whose officers are more largely engaged in purely scientific investigations. The relative value of the two lines of work can, however, hardly be compared on a commercial basis, as perhaps the results of a single, purely scientific investigation may eventually have a broader application in actual practice, and be of greater value than work which is of immediate interest. The results accomplished are, however, complimentary, and thus more useful to the general public than if only one of the lines of work were pursued; for the demands of those who need immediate help are satisfied, while at the same time new facts are secured and new principles established, upon which the success and progress of the industry

must depend. That the objects and purposes in the establishment of the institutions have been closely adhered to in the work of the past year, is made abundantly evident in the reports of the various officers herewith submitted.

Analyses of Commercial Fertilizers.

A change in the method of securing samples of fertilizers this year by the appointment of an officer of the Station as inspector, instead of county inspectors, was adopted, and has given great satisfaction; it is an improvement over the old method in two directions. First, in that the work of inspection is completed earlier in the season; and second, the single inspector making this work his whole duty is able to secure more complete representation of the various brands upon the market.

The chemists report this year the analyses of 399 samples of complete fertilizers, 26 samples of ground bone and 48 samples of miscellaneous products, a total of 473 samples, an increase over last year of 25 per cent. in the number of brands examined. There have been no cases of direct adulteration discovered, though there are a number of brands where wide variations from the guarantee are shown, due undoubtedly to imperfections or carelessness in methods of manufacture. The cost of manufacture and sale varies but slightly from that shown to be the average in previous years, and the average cost of plant-food is but little higher.

There are also reported the analyses of 60 samples of standard fertilizing materials, 20 special mixtures and 3 home mixtures. The number of analyses of standard materials required is practically identical with those reported last year; the decrease in the number of analyses of this sort in the past few years is in a large degree the result of the education of the farmer by the Station in the matter of how to purchase plant-food, which in its earlier history was a prominent line of investigation, and from the standpoint of direct value has been probably of greater usefulness than any other one line of the Station's work. The progressive farmer is now educated; he knows that in the purchase of fertilizers value depends, not upon the name of the manufacturer or his brand, but upon the kind, the quantity and the quality of the plant-food constituents that are furnished.

The Station has also, as a result of its studies of the fertility-need of the various soils and crops chiefly by means of field experiments

with fertilizers, been able to give the farmer information as to the probable requirements of the various crops; hence, with positive information concerning what constitutes fertilizers, and more or less accurate ideas as to the probable needs of his crops, the farmer has abandoned his "hit or miss" methods of purchase and use, and has adopted a more reasonable mode of procedure. He is now guided by the underlying principles which are involved, and as a result of this evolution in methods, his purchases are direct from the manufacturers, either as raw materials, or mixed according to formulas, which his judgment dictates as best suited for his conditions.

The samples of miscellaneous products include many substances whose composition is not definite, and the object of the analyses is to determine their usefulness as soil amendments, or as direct fertilizers. In many cases wastes are discovered which are valuable and of very great service in the locality in which they are found.

Analyses of Commercial Feeds.

In carrying out the provisions of the law requiring an inspection of concentrated feeds, the Station has adopted a broad view of it, and not only has included in its work the products which required inspection, but has made a chemical study of the two staple feeds, wheat bran and corn meal, in order to determine chiefly the variations in their composition and feeding value.

In the carrying out of this work, the analyses of 595 different samples were required. These, together with a very complete and detailed study of the various kinds and classes of feeds, were published in Bulletin No. 160. In fact, the bulletin is a complete monograph on the subject of commercial concentrated feeding stuffs. The Station in this work furnishes farmers, dealers and manufacturers with definite information in regard to the composition and relative value of the different materials on the market. This work, it is believed, is of the highest importance, though the continuation of so detailed a study of it will not be required in future, as that already published will be sufficient for some time to come.

In the course of the inspection early in the year, a number of spurious materials were discovered, which, though sold as feeds, are properly termed "feed substitutes." The very great importance, both to the producers of genuine articles and to consumers, of a knowledge of the character and composition of these materials, was so apparent that their investigation was rapidly prosecuted, and the

results published at once in Bulletin No. 156. Fortunately, for the feeders of the State, very little evidence was found of the use of these spurious articles in the making of mixtures, and very shortly after the distribution of the bulletins, the manufacturers of the most objectionable of the articles removed this business from the State. The multiplication of products suitable for feed, due to the increase and improvement in manufacture, makes the constant supervision of the character here reported of very great service, both from the standpoint of protection and of education.

The very large amount of work involved in the inspection and analyses of fertilizers and feeds is only possible because of the gradual improvement in the methods of analyses, which has materially shortened the time required for many determinations. This work is of the highest importance, and the chemists devote much time to such study.

Chemical Investigations.

In addition to the work of the laboratories as already pointed out, investigations involving the chemical analyses of numerous samples of experimental crops have been made. The farm crops requiring analyses are those obtained in experiments designated to test their adaptability and usefulness for our conditions, and thus serve as either additions to, or as subtitutes for, crops now regularly in use.

Plant Nutrition.

Other scientific investigations which required a chemical control called for the analyses of 294 samples. These investigations have for their object, a study of the relative value of the nitrogen in different materials, the changes and losses that occur in the handling of yard manure, the value of the constituents in the manures, when carefully and when wastefully handled, and the relative value of the constituent nitrogen in these manures as compared with best forms in artificial materials. Naturally, in investigations of this sort, positive facts cannot be obtained without subjecting every step in the process of the experiment to a rigid examination. The analyses must include the soil, the manure and the plant, and the work must continue until such a number of crops have been included, and seasons covered as to provide for the variations liable to occur. This work also permits the further study of possible losses of nitrogen contained in soils and in manures, due to the action

of unfavorable organisms that may exist in them. The results thus far obtained are very striking, and show the losses that are liable to occur in the present methods of use of farm manures, though they do not prove that the losses are entirely due to their careless use. The very great and far-reaching importance of a study of these points, and of the chemical and biological relations of soils, confirm the wisdom of the managers in establishing a laboratory for the study of such relations. Its first report is incorporated herewith. In connection with the careful and required laboratory studies of plant nutrition, field experiments were also carried out to study the relative effect of nitrate of soda as a source of nitrogen, and Bulletin No. 157, entitled "Field Experiments with Nitrate of Soda on Market Garden Crops," was published.

Soil Chemistry and Bacteriology.

The investigations included a preliminary examination of the typical soils of South Jersey, a study of the losses of nitrogen from solutions inoculated with pure cultures and with mixtures of bacteria, and the individual peculiarities of the different organisms. In the study of the morphology of denitrifying bacteria, four organisms were isolated, the first one of which is distinct from any hitherto described, and was named Bacillus New Jersey. Another one resembling B. New Jersey, and yet possessing some marked differences, was classed as a variety of it and called B. New Jersey variety. The other two are symbiotic, that is, destroy nitrates with the liberation of gaseous nitrogen only when growing together.

The studies in the physiology of denitrification included observations of the conditions of denitrification, particularly as to the organic compounds best suited to the denitrifying organisms for the destruction of nitrates. The amounts of nitrate nitrogen transformed into organic combinations, and the amounts set free were determined, and attempts made to determine whether denitrifying bacteria can under certain conditions also fix atmospheric nitrogen.

The chemical work involved required in all about 200 nitrogen determinations and about 125 determinations of volatile matter in different soils and 450 nitrogen determinations of cultures and culture solutions.

HORTICULTURE.

In this department, the field work is materially increased from year to year, as the various varieties of fruits come into bearing. The season was not favorable for blackberries and raspberries, but very favorable for tree fruits. Large crops of cherries, plums and peaches were obtained, and the influence of the different methods of manuring is becoming more apparent each year; a number of the varieties of pears and apples also came into bearing for the first time this year, though differences due to different treatment are not yet observable. The very great advantage of a careful selection of varieties of asparagus is, however, very marked again this year, the Palmetto showing a greater resistance to disease, and a much larger yield than any other variety, though the treatment was identical in each case. Experiments on the irrigation of asparagus and small fruits were continued, and the results prepared for publication. Experiments in the forcing-houses have been continued, both to learn what crops are best adapted for commercial purposes, as well as the methods of manuring and treatment best adapted for each. Thus far tomatoes, cucumbers, lettuce, cauliflower and beets have been shown to be well adapted for the purpose, though tomatoes and cucumbers are much more profitable than the others. No method of fertilization adopted has been shown to be superior to stable manure, though the method of use of the manure is an important matter.

DAIRY HUSBANDRY.

In this department of the Station work, the study of the adaptability and usefulness of various forage crops, and of the use of the soiling system for the dairy, have been continued. During the year the results of the experiments with the growth and feeding of the various forage crops have been published; Bulletin No. 158, entitled "Soiling Crop Experiments," has created a very marked interest on the part of farmers in this, as well as in other States, and a marked improvement in the dairy farm practice of the State is already noticeable as a result of the Station's experiments along this line during the past few years. The field experiments in the growth of alfalfa, crimson clover and cow peas, and their use as substitutes for fine feeds, were continued, and the results published in Bulletin No. 161, entitled "Alfalfa, Cow Peas and Crimson Clover as Substitutes for Purchased Feeds. Home-Grown Protein versus Purchased Protein."

This line of work has for its object the encouragement of the growth of a larger number of legumes, or protein crops, which, if made into hay and fed with corn silage, the great carbohydrate crop, will reduce the need for the purchase of protein feeds. The results of the experiments showed, for example, that when milk is worth $1 per hundred, the gain from feeding home-grown rations, rather than those which required the purchase of protein, amounted to about $2 per cow per month, and also that home-grown crops could, with this price for milk, be utilized in the dairy at a greater profit than could have been realized from selling them at the market prices. These points are of vital interest in our dairy sections particularly, and if observed will result not only in causing larger direct profits from feeding, but in the improvement of the soil, and consequently increased crops.

The experiments conducted to determine the advantages of top-dressings of nitrate of soda for the early and summer forage crops, rye, wheat and millet, showed the very great advantage and profit of this method of practice.

The farm and its equipment, which make these experiments possible, do not, as many believe, belong to the State, but are the property of Rutgers College and loaned to the Station for experimental purposes. The farm must therefore be self-supporting; hence the products of the dairy are sold. This situation is taken advantage of in order to study, not only the economical production of milk, but also the problems connected with its preparation and handling for the retail trade. The actual data thus obtained are extremely useful in showing the necessary losses and expenses involved in handling and selling milk, and the relative advantages of its wholesale and retail disposal. A report of the operations of the farm in considerable detail, together with a financial statement, is made each year to the Board of Trustees of the College, and it is hoped that the data contained in these reports may be arranged for publication.

In most States the Experiment Farm is owned and the equipment provided by the State, and the expenses of carrying out the experiments paid entirely from the funds specially appropriated by the State, thus not necessitating close business methods in the sale of products in order to meet the expenses. Where the farm is supported by its income, as here, it would seem that the State might well make special appropriation for its more complete equipment in order that it may serve a better purpose as an object-lesson in all that pertains to modern practice to the farmers of the State, who

now regard it as of great practical service. Visitors come from all parts of our own State and from other States; they are not all interested in the same things, and a better equipment in stock and in machinery than the farm can afford from its own income would add materially to the value of this feature of the Station's work, now regarded as the one of most direct value to the practical farmer.

Where the sole purpose of the farm is for instructive experiments, the line of experimentation should not be influenced by business considerations, notwithstanding the many advantages of having an experiment farm conducted on a business basis, as has been pointed out.

BIOLOGY.

In this department the work of the Biologist in the study of questions connected with oyster culture, which was begun last year, has been continued. The principal need of those engaged in the oyster industry is a method of raising seed oysters that shall be tolerably certain in its results. In the first report special attention was given to the early development of the oyster egg before it gives rise by hatching to the swimming fry. In this year's report the next succeeding stage of development has received attention, namely, the stage preceding the fixation of the spat. Therefore, during this season, particular attention was given to the comparison of the eggs of different varieties of oysters in regard to their power of development. Contrary to anticipation, it was found that "Southern Plants" produced fry of stronger viability than any other oysters. Some attention was also given to tank culture of the fry, but this part of the subject is the ultimate goal of the studies, and cannot be given attention until after the determination of the effects of variations in temperature and salinity of the water on the contained fry.

The report of the Biologist also contains records of tuberculin tests and autopsies of tuberculous cows, the last of the herd that has been for eight years under observation and experiment.

BOTANY.

For the year 1902, the work in the Botanical Department has been chiefly divided between experiments upon the trial grounds and in the greenhouse.

Much time and attention have been given to the breeding of truck crops, supplemented with variety testing. Thus the crossing between the "Henderson" and "Burpee" dwarf lima beans has progressed, and the beginnings of new sorts are in sight that combine important qualities. In this work a number of crosses that are climbers have developed, thus giving rise to pole sorts that may prove of value.

With eggplants, the present season has been occupied with the testing of a cross between the "Long Purple" and the "New York Improved," with the result that this new and somewhat bell-shaped variety is superior to any of a large number of standard sorts that were grown for comparison.

The work in breeding tomatoes has gone on in both field and greenhouse, with additional hope of gaining a combination that will bring fruits with but few seeds, and a high quality of flesh.

Breeding for a smooth (spineless) cucumber is in progress. Last winter a cross was secured between the "Telegraph"—a variety remarkable for its length and seedlessness—and a celebrated Austrian sort (Znaim) that has fruited in the field, and may prove an acquisition.

In crossing sweet corn, a pink sort has been nearly established from the "Black Mexican" and "Egyptian," though further work in selection is still needed to give uniformity to the number of rows to the ear and other desirable features of a distinct breed.

Fungicide work has been continued, particularly in the greenhouse. It has been determined that mildew has an effective remedy in kerosene emulsion. It still remains to establish the most economical method of applying the mixture. A study is being made of the conditions favoring the growth of mildew under glass.

Experiments with dodder and other parasitic plants, as broomrape, are also in progress.

Observations as to the prevalence of asparagus rust have been made through the season, and by correspondence with other Station workers, some additional facts as to its habits have been obtained.

Bulletin No. 151, "Bean Diseases and Their Remedies," was issued by this department during the year.

ENTOMOLOGY.

The principal work of the season was the beginning of an investigation of the mosquito problem, and excellent results have been already obtained, which promise the ultimate success of the study. The facts ascertained concerning the salt marsh mosquito were deemed so important that Special Bulletin "T" was issued in July. The other lines of work have not yet advanced far enough to make final reports possible.

The occurrence of Brood XXII. of the Periodical Cicada gave opportunity to fix its distribution in the State, and as all the broods known to occur in New Jersey have now made their appearance during the period which the Entomologist has held office, a full summary of their distribution is contained in his report.

The results of the work in the experiment orchard were collated and published in Bulletin No. 155. The rose scale having increased so as to become injurious, the results of the studies and experiments made were published in Bulletin No. 159. During the late winter and early spring, the applications of lime, salt and sulphur in orchards infested with the San José sçale were watched, and in part directed, and the effects of the wash were noted at intervals throughout the summer. The results of these observations, together with those of experiments in other States, were presented in Bulletin No. 162, issued in October.

Numerous inspections of nurseries and orchards were made in all sections of the State, and there is no county that has not been visited at some period of the year in an official capacity by the Entomologist.

The usual lines of current work, such as testing insecticides, investigating local outbreaks, determining the character of insects complained of and suggesting remedies, occupied what little time remained. The collections of the department continue to increase, and in their care, Mr. E. L. Dickerson, assistant to the State Entomologist, gives material aid. Several cases have been prepared for exhibition in the State museum at Trenton.

FARMERS' MEETINGS.

The work of the Station is not limited to scientific investigations or practical experiments. It aims as far as possible to carry the results of the work to the farmer in the field, and as in the past, various officers of the Station have heen present at meetings of farmers throughout the State. Owing to the advances in the thought and work of the farmer, this requires more time and work on the part of the officers than heretofore. The Station also serves as a bureau of information, not only in matters pertaining directly to farming, but in many other matters, only indirectly connected with the farm, but of interest to the general public.

EQUIPMENT.

The various departments are well supplied with the needful scientific appliances and apparatus. Many new pieces of apparatus are annually required in order to do advanced work.

The library is well supplied with the important technical works, standard periodicals and journals, connected with the science of agriculture, and many additions are annually made. Much progress has also been made during the year in securing complete files of Station literature.

REPORT OF THE CHEMISTS.

REPORT OF THE CHEMISTS.

FERTILIZERS.

ANALYSES OF FERTILIZER SUPPLIES, HOME MIXTURES AND SPECIAL COMPOUNDS.
ANALYSES AND VALUATIONS OF COMMERCIAL FERTILIZERS AND GROUND BONE.

1. *Introduction.*
2. *The trade values of fertilizing ingredients for 1902, and the examination of the standard materials supplying them.*
3. *The examination and valuation of home mixtures and special compounds.*
4. *The examination and valuation of manufactured brands and sundry materials.*

1.

INTRODUCTION.

On the following pages is reported the work of the Station relating to fertilizers and fertilizing materials during the past year. This work has been steadily increasing until now it is of greater magnitude than ever before, and has completely occupied the time allotted to it. In this connection, it becomes necessary to state that since the Station has been charged with the inspection, along the same lines, of the feeding stuffs to be found in the State, the demands upon the time of the Station's staff are such as to require concentrated effort upon systematized work. From April 1st to October 1st, therefore, has been allotted to the examination of fertilizers, and from November 1st to March 1st to the examination of feeds. In order

to serve the public to the best advantage, the Station regretfully announces that it has become obligatory that the examination of neither fertilizers nor feeding stuffs be undertaken out of their proper season.

In connection with the inspection of feeds, Mr. W. P. Allen was in 1901 permanently added to the Station's staff, and to him solely was assigned the duty of collecting the samples throughout the entire State. Mr. Allen's services being available, the same system was this year applied to the collection of the fertilizer samples. The system has been equally successful, and the Station only regrets the severance of its relations with the local inspectors, many of whom had been doing this work for years, solely because it was regarded by them as a matter of vital interest to the farming public.

The inspection this year has been quite thorough ; twenty of the twenty-one counties of the State have been visited, and 750 samples drawn and shipped to the Station. As fast as received, they have all been recorded under a distinguishing number. From among the duplicates of each brand a selection for analysis has been made, with the aim that the samples of any one firm shall be from different portions of the State, and represent their largest stocks.

This method of selection, it is believed, is more likely to demonstrate the general quality of the fertilizer output, and less likely to cause insinuation or distrust than if the samples for analysis were selected upon request.

Under certain conditions, however, exceptions to this rule are allowed. When purchases amounting to twenty tons or more are to be paid for according to the Station's analysis, or when the analyses will add to the information of the Station, or will demonstrate a possible development of waste products into cheap sources of plant-food, or in other ways is of general interest, the Station performs the work. In all cases this is done free of charge, but full and sufficient particulars are required, so that the analyses may be of service to the general public.

The following is a list of those business houses the analyses of whose goods are published in this report :

Manufacturers

WHOSE GOODS HAVE BEEN SAMPLED AND ANALYSED THIS YEAR.

J. H. Allen & Son .... Lawrence Station, N. J.
Allentown Manufacturing Co .... Allentown, Pa.
American Agricultural Chemical Co .... 26 Broadway, New York City.
 Bradley Branch .... No. 92 State St., Boston, Mass.
 Chicopee Guano Branch .... No. 88 Wall St, New York City.
 Clark's Cove Branch .... No. 81 Fulton St., New York City.
 Crocker Branch .... No 56 Pearl St., Buffalo, N Y.
 East India Branch .... No 93 William St., New York City.
 Great Eastern Branch .... Rutland, Vt.
 Milsom Branch .... No. 963 William St., East Buffalo, N. Y.
 Pacific Guano Branch .... No. 27 William St., New York City.
 Packer's Union Branch .... No. 150 Nassau St., New York City.
 Moro Phillips Branch .... No. 710 The Bourse, Philadelphia, Pa.
 Preston Branch .... Greenpoint, L. I., N. Y.
 Quinnipiac Branch .... No. 83 Fulton St., New York City.
 Read Branch .... No 16 Exchange Place, New York City.
 Sharpless & Carpenter Branch .... No. 710 The Bourse, Philadelphia, Pa.
 Susquehanna Branch .... Baltimore, Md.
 Tygert-Allen Branch .... No. 2 Chestnut St., Philadelphia, Pa.
 Wheeler Branch .... Rutland, Vt.
 Williams & Clark Branch .... No. 27 William St., New York City.
Armour Fertilizer Works .... Baltimore, Md.
Warren Atkinson .... Mullica, Hill N. J.
J. H. Baird .... Marlboro, N. J.
Baugh & Sons Co .... No. 20 S. Delaware Ave., Philadelphia Pa.
The Berg Co .... Russell and Bath Sts., Philadelphia, Pa.
Berger Bros .... Easton, Pa.
Bowker Fertilizer Co .... No. 43 Chatham St., Boston, Mass.
Bradley & Green Fertilizer Co .... Ninth St. and Girard Ave., Philadelphia, Pa.
Wm. M. Brown .... Cedarville, N. J.
C. C. Clark & Son .... Mount Ephraim, N. J.
E Frank Coe Co .... No. 133 Front St., New York City.
John S. Collins & Son .... Moorestown, N. J.
Collins & Pancoast .... Merchantville, N. J.
Peter Cooper's Glue Factory .... No. 13 Burling Slip, New York City.
G. & W. H Corson .... Plymouth Meeting, Pa.
A. A. Cortelyou .... Neshanic Station, N. J.
I. S. Curtis .... Frenchtown, N. J.
Davis, Colson & Co .... Woodstown, N. J.
B. F. Demaris & Son .... Cedarville, N. J.
J. H. Denise .... Freehold, N. J.
H. W. Doughten .... Moorestown, N. J.
J. G. Downward & Co .... Coatesville, Pa.
Frank Emmons .... Newton, N. J.

J. C. Fifield & Sons Co.	Bakersville, N. J.
Fithian & Pennell	Bridgeton, N. J.
W. O. Garrison	Bridgeton, N. J.
J. C. Griscom	Woodbury, N. J.
Wyckoff Hendrickson	Allentown, N. J.
S. M. Hess & Bro	4th and Chestnut Sts, Philadelphia, Pa.
G. C. Higgins & Son	Three Bridges, N. J.
Ira Hill	Copper Hill, N. J.
Hill & Co	Flemington, N. J.
Hires & Co	Quinton, N. J.
W. B. Hitchner	Woodstown, N. J.
The Hubbard Fertilizer Co	Merchants' Bank Building, Baltimore, Md.
International Seed Co.	Rochester, N. Y.
John Joynt	Lucknow, Ontario, Canada.
Kirkwood Marl Co	Kirkwood, N. J.
Hervey Kuhl	Flemington, N. J.
Lackawanna Fertilizer and Chemical Co	Moosic, Pa.
Samuel Lederer & Sons	New Brunswick, N. J.
Lister's Agricultural Chemical Works	Newark, N. J.
The Mapes F & P Guano Co	No. 143 Liberty St, New York City.
John E. Minch	Bridgeton, N. J.
Mitchell Fertilizer Co	Tremley, N J.
Mixner & Mickel	Bridgeton, N. J.
Monmouth Fertilizer Works	Shrewsbury, N. J.
L. Moritz	No. 1321 N. 5th St., Philadelphia, Pa.
The Nassau Fertilizer Co	No. 5 Beaver St., New York City.
O. F. Neidt	White Horse Station, Trenton, N. J.
Albert Nelson & Co	Allentown, N. J.
New Jersey Agricultural Chemical Co	Newark, N. J.
Newport Fertilizer Co	No. 407 Drexel Building, Philadelphia, Pa.
James E. Otis	Tuckerton, N. J.
R. R. Outcalt	New Brunswick, N. J.
S. L. Pancoast	Mullica Hill, N. J.
Peterson & Smith	Woodstown, N. J.
R. H. Pollock	No. 51 S. Gay St., Baltimore, Md.
Quaker City Poudrette Co	No. 19 N. Juniper St., Philadelphia, Pa.
John Repp	Glassboro, N. J.
Enos Richmond	Elmer, N. J.
Edward Rigg, Jr	Burlington, N. J.
M. F. Riley	Elmer, N. J.
Ruckman Bros	New Brunswick, N. J.
C. W. Saul	Rio Grande, N. J.
Sharpless & Bro	Camden, N. J.
M. L. Shoemaker & Co	Delaware Ave. and Venango St., Philadelphia, Pa.
Lester Shurts	Neshanic Station, N. J.
L. W. Sickler	Glassboro, N. J.
Jos. Smith & Co	Stockton, N. J.
Rufus W. Smith	Elmer, N. J.
Somerset Chemical Co	Bound Brook, N. J.

Henry Taylor	Vineland, N. J.
Taylor Bros	Camden, N. J.
The Taylor Provision Co	Trenton, N J.
I. P. Thomas & Son Co.	No. 2 S. Delaware Ave., Philadelphia, Pa.
Trenton Bone Fertilizer Co.	Trenton, N. J.
*The J. E. Tygert Co	No. 42 S. Delaware Ave., Philadelphia, Pa.
Vineland Grain Co	Vineland, N. J.
J. K. Waddington	Salem, N. J.
Emil Wahl Manufacturing Co	No. 3370 Pulaski Ave., Nicetown, Philadelphia, Pa.
Geo. M. Wells	Moorestown, N. J.
J. Wenderoth & Sons	Camden, N. J.
West Jersey Marl and Transportation Co	Woodbury, N. J.
W. E. Whann	William Penn, Pa.
White Rock Lime Co	McAfee, N. J.
W. Wilde	Vineland, N. J.
Winterbottom, Carter & Co	Egg Harbor City, N. J.
Woodward & Dixon (Brokers)	New York City.
Wrightsville Lime Co	Wrightsville, Pa.
Young & Hoffman	White House, N. J.

The inspection of fertilizers this year has required the following analyses :

394	samples of Complete Commercial Mixtures,
28	" " Incomplete Commercial Mixtures,
26	" " Ground Bone,
60	" " Fertilizing Raw Materials,
3	" " Home Mixtures,
20	" " Specially Compounded Mixtures,
20	" " Sundry Materials,
5	" " Complete Fertilizers of last year's stock.
556	

The analyses do not reveal any flagrant attempt at fraud, although the crude preparation of many brands, and the variations which appear when duplicate samples are analysed, would indicate that a considerable proportion of those engaged in the business are not possessed of the ordinary facilities required to secure a proper mechanical condition or uniformity, or they do not have a proper appreciation of the importance of these points. On the other hand, the wide variations in the cost per pound of the constituents in the different brands, even in brands from the same manufacturer, and the fact that certain brands are able to stay on the market, would indicate that farmers as a class are prone to consider fertilizers by the name or by the bag, and do not properly appreciate the guarantee and the determinative effect it should have on the price demanded. While there have been shortages in the amount of plant-food

delivered, the fraud, when there has been one, has in most cases been perpetrated by the farmer upon himself in buying in the dearest market.

Farmers should aim to reduce the cost of their fertilizer supplies to as near Station's schedule of prices as possible, for very close to these are the prices at which not only raw materials, but also finished mixtures have been purchased this year. In the absence of an analysis from which to compute the valuation, the guarantee may be used. Valuing ammonia at $3 for every whole per cent. in the guarantee, and available phosphoric acid and actual potash likewise at $1 each, a rough valuation may be reached from which the actual price should not depart materially. In this manner, a fertilizer guaranteed to contain 3 per cent. of ammonia, 8 per cent. of available phosphoric acid and 7 per cent. of actual potash should furnish ammonia (or nitrogen) worth $9, phosphoric acid worth $8, and potash worth $7, or plant-food worth a total of $24 per ton. These are the figures at which it has actually been furnished on the average in twenty mixtures made by regular manufacturers at their factories, but on special order in relatively large lots for farmers' organizations, and for cash. While these features have undoubtedly had their influence in rendering the prices so favorable, there are numerous instances of very good bargains in the ready-made goods. On the average, however, the prices of the latter range higher and show an advance of $6.34 per ton over manufacturers' actual prices in their special brands. These special brands are mostly higher grade than the average complete fertilizer; comparing, therefore, on an equal quantity of plant-food, we may say that a ton containing twenty dollars' worth at Station's valuation has cost $21.27 in the specially mixed and $25.94 in the regular brands. These are average figures, and two-thirds of the manufacturers sell their regular brands at this rate. On the other hand, there are twenty-eight manufacturers who furnish twenty dollars' worth of plant-food at from $26 to $32, and three charge from $32 upwards, the highest asking $41.40 for twenty dollars' worth, or more than double, and $15 more than two-thirds of the manufacturers' charge.

From these considerations, it will appear that there will be a decided financial gain from the use of good business methods in the purchase of fertilizer supplies, as well as in the sale of the crop which results; caution in this respect should not be relinquished simply because the analysis substantiates the guarantee; it should also substantiate the selling price.

2.

THE TRADE VALUE OF FERTILIZING INGREDIENTS FOR 1902.

The estimated commercial value of fertilizers, it must be clearly understood, is separate and distinct from the agricultural value, the latter depending upon the character and form of the materials with reference to their availability, and the needs and value of the crop for which they are to be applied. The former, on the other hand, is determined by market and trade conditions, such as supply and demand, the cost of production, the methods of manipulation required, etc. It is derived by applying to the various forms of plant-food ingredients, as shown by analysis, the values previously determined upon for them. These values are fixed from year to year, and are altered according to the cost of the standard materials containing these forms of plant-food, as shown in market reports and actual transactions.

The wholesale prices of crude products, or raw materials, are quoted every Monday in the well-known trade journal, *The Oil, Paint and Drug Reporter*. These prices have been tabulated for the entire year, and have then been recalculated in order to express them as prices per pound of actual plant-food, which is the form adopted by the Experiment Stations of this country. The recalculation has been made upon the basis of the following analyses :

Nitrate of Soda	16	per cent.	Nitrogen.
Sulphate of Ammonia	20½	"	"
Dried Blood	12½	"	"
Acid Phosphate	12	"	Available Phosphoric Acid.
High-Grade Sulphate of Potash	50	"	Potash.
Double Sulphate of Potash and Magnesia	25	"	"
Muriate of Potash	50	"	"
Kainit	12½	"	"

On account of the fact that the report of the Experiment Station is made up on October 30th of each year, the results which appear in tabular form are for the year 1901. During that year the prices of the nitrogen-furnishing materials fluctuated somewhat, becoming stronger toward the close of the year. As it is probably at this time that the manufacturers of mixed goods place their contracts for raw materials, the quotations for the last four months of 1901, and the first two months of 1902, have been averaged as a more suitable basis for the determination of the schedule of valuations for 1902.

Wholesale Cost, Per Pound, in New York—

MONTHS.	Of Nitrogen in Form of—						Of Phosphoric Acid in Form of—		Of Potash in Form of—							
	Nitrate of Soda.		Sulphate of Ammonia.		Dried Blood.		Acid Phosphate.		Kainit.		Muriate of Potash.		Double Sulphate of Potash and Magnesia.		High-Grade Sulphate of Potash.	
	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
	cts	cts.	cts.	cts.	cts.	cts.	cts.	cts.	cts.	cts.	cts.	cts.	cts.	cts.	cts.	cts.
January	11.5	11.4	13.8	13.6	14.1	13.9	3.3	3.0	3.8	3.6	3.7	3.7	4.3	4.2	4.2	4.1
February	11.5	11.4	13.7	13.6	14.3	14.3	3.3	3.0	3.8	3.6	3.7	3.7	4.3	4.2	4.2	4.1
March	11.5	11.8	13.6	13.5	14.6	14.6	3.3	3.0	3.7	3.5	3.7	3.7	4.6	4.5	4.3	4.2
April	11.5	11.4	13.4	13.0	14.3	14.3	3.3	3.0	3.7	3.5	3.7	3.7	4.6	4.5	4.3	4.2
May	11.9	11.5	13.6	13.4	14.8	14.0	3.3	3.0	3.7	3.5	3.7	3.7	4.6	4.5	4.3	4.2
June	12.1	11.7	13.4	13.2	14.2	13.9	3.3	3.0	3.7	3.5	3.7	3.7	4.6	4.5	4.3	4.2
July	12.3	11.6	13.3	13.2	14.0	14.0	3.3	3.0	3.7	3.5	3.7	3.7	4.6	4.5	4.3	4.2
August	12.8	12.0	13.8	13.2	13.9	13.6	3.3	3.0	3.7	3.5	3.7	3.7	4.6	4.5	4.3	4.2
September	12.2	12.0	13.6	13.5	13.7	13.4	3.3	3.0	3.7	3.5	3.7	3.7	4.6	4.5	4.3	4.2
October	12.1	11.9	13.8	13.7	14.0	14.0	3.3	3.0	3.7	3.5	3.7	3.7	4.6	4.5	4.3	4.2
November	12.1	11.9	13.8	13.7	13.9	13.8	3.3	3.0	3.7	3.5	3.7	3.7	4.6	4.5	4.3	4.2
December	12.2	11.9	13.6	13.5	13.5	13.1	3.3	3.0	3.7	3.5	3.7	3.7	4.5	4.5	4.3	4.2
Average for 1901	11.8		13.5		14.0		3.1		3.6		3.7		4.5		4.2	
Average for 1900	11.6		14.2		14.0		3.2		3.7		3.7		4.2		4.1	
Average for 1899	10.4		14.4		11.1		3.3		3.7		3.6		4.2		4.0	

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The wholesale prices per pound of plant-food prevailing in New York during the six months immediately preceding March 1st last, were for nitrogen in nitrate of soda, 12.4 cents, in sulphate of ammonia, 13.8 cents, and in high-grade dried blood, 13.7 cents; for available phosphoric acid in acid phosphate, 3.1 cents; and for actual potash in muriate of potash, 3.7 cents, in kainit, 3.6 cents, in double sulphate of potash and magnesia, 4.5 cents, and in high-grade sulphate of potash, 4.3 cents. A comparison of these figures with those of last year will show that there have been advances in the market prices, particularly of the ammoniates, or nitrogen-furnishing materials, blood excepted.

From these wholesale prices, as a basis, the following schedule of trade values was arranged at a meeting of Station Directors and Chemists for use in Connecticut, Massachusetts, New York, Rhode Island, Vermont and New Jersey during the season of 1902:

Schedule of Trade Values Adopted by Experiment Stations for 1902.

	Cents per pound.
Nitrogen in Nitrates	15.0
" " Ammonia Salts	16.5
Organic Nitrogen in dried and fine-ground fish, meat and blood, and in mixed fertilizers	16.5
" " " fine-ground bone and tankage	16.0
" " " coarse bone and tankage	12.0
Phosphoric Acid, soluble in water	5.0
" " " " ammonium citrate*	5.0
" " insoluble in fine bone and tankage	4.0
" " " " coarse bone and tankage	3.0
" " " " mixed fertilizers	2.0
" " " " fine-ground fish, cotton-seed meal, castor pomace and wood ashes	4.0
Potash as Muriate	4.25
" " Sulphate, and in forms free from muriates (or chlorids)	5.0

Valuation of Fertilizing Ingredients in Fine-Ground Feeds.

Organic Nitrogen	14.5
Phosphoric Acid	4.0
Potash	5.0

*The solubility of phosphates, in ammonium citrate solutions, varies with the degree of heat. An act of the Legislature (see Laws of New Jersey, 1874, page 90), provides that in this determination the temperature used shall not exceed 100° Fahr.; in other States 150° Fahr. has been adopted. Consequently the Station valuation of phosphoric acid, soluble in ammonium citrate has been fixed at *four and one-half cents* per pound for Connecticut, Massachusetts, New York, Rhode Island and Vermont, and at *five* cents per pound for New Jersey.

The Examination of Unmixed Fertilizing Materials.

The results of analysis of sixty samples of standard unmixed raw materials appear in tabulated form upon subsequent pages. This work is of particular value in that it directs the attention of fertilizer consumers to the composition and use of standard fertilizing supplies, and suggests rational and economical methods of purchasing plant-food. The samples include nitrate of soda, dried blood, dried and ground fish, tankage, plain superphosphate, muriate and sulphate of potash and kainit. The samples would indicate that the goods represented were generally of good quality, although the usual variability is to be seen in the case of blood, fish and tankage. The greater part of them appear to be economical purchases, but there are the usual prominent exceptions. Since the samples represent goods actually on the market at the prices given, the average cost per pound of their several ingredients may be fairly assumed to represent the average prices at factory for nitrogen, phospheric acid and potash. These average prices are 14 cents per pound of nitrogen in nitrate of soda, 16.3 cents in dried blood and the fine-ground tankages, and 18.2 cents in dried and ground fish, 3.9 cents per pound of available phosphoric acid in plain superphosphates, and 4.1 cents, 5 cents and 4.8 cents per pound of actual potash in muriate of potash, sulphate of potash and kainit, respectively.

The raw materials on the average were, therefore, secured practically at Station's prices, the principal exception being dried and ground fish; all but two of the samples of this material are dealers' samples, and were sold in the same way, and to a degree with the same profits as the regular complete fertilizers, which explains the exception.

3.

THE EXAMINATION OF HOME MIXTURES AND SPECIAL COMPOUNDS.

Home mixing by farmers has been carried on with entire satisfaction for a number of years. The Station has encouraged and assisted in these efforts as of value to the individuals themselves, and an object-lesson to their neighbors. Less assistance, however, in the shape of analyses, etc., is now being required of the Station for

several reasons: First, the more experienced have ceased to request assistance; second, many who mix for themselves mix for their neighbors as well and become in a way manufacturers; their mixtures are sampled in the regular way, and are published with the regular brands; and third, a growing number of individuals, farmers' clubs, granges, etc., direct and govern the composition of their fertilizers, but have the mixing done especially for them at the fertilizer manufactory.

The analyses of three home mixtures and of twenty special mixtures are published herewith. In certain of the latter, merely the guaranteed analysis, which is given in the tables, was required of the manufacturer; in others, the use of certain ingredients was insisted upon; the ingredients of the home mixtures and of the others, reported to us, were as follows:

Composition.

Home Mixtures.	Special Mixtures.
No. 1687.	No. 2399.
209 lbs. Dried Fish.	400 lbs. Dried Fish.
400 " Ground Bone.	500 " Steamed Bone.
800 " Acid Phosphate.	700 " Acid Phosphate.
225 " Muriate of Potash.	400 " Muriate of Potash.
No. 2724.	No. 2400.
100 lbs. Nitrate of Soda.	100 lbs. Nitrate of Soda.
100 " Dried Blood.	100 " Sulphate of Ammonia.
500 " Dissolved Tankage.	250 " Dried Fish.
125 " Dried Fish.	500 " Steamed Bone.
500 " Acid Phosphate.	700 " Acid Phosphate
200 " Ground Bone.	350 " Muriate of Potash.
475 " Muriate of Potash.	
No. 2576.	No. 2350.
200 lbs. Nitrate of Soda.	200 lbs. Nitrate of Soda.
100 " Sulphate of Ammonia.	400 " Dried Fish.
100 " Dried Blood.	1,000 " Dissolved Bone.
800 " Degelatinized Bone.	400 " Muriate of Potash.
500 " Acid Phosphate.	
400 " Muriate of Potash.	

The following table shows the average composition of the Home Mixtures and Special Mixtures, together with their average value and cost, and the difference between the same:

	Total Nitrogen.	Total Phos. Acid.	Available Phos. Acid.	Insoluble Phos. Acid.	Potash.	Station's Valuation.	Selling Price or Cost.	Actual Difference.
Home Mixtures	2.38	13.77	10.87	2.90	9.76	$27 99	$24 62	$2 37
Special Mixtures	2.33	10.67	8.02	2.65	7.04	22 70	24 14	1 44

The home mixtures, therefore, cost on the average $2.37 less than Station's valuation, and the special mixtures $1.44 more, a difference of $3.81.

Inasmuch as most of the unmixed materials coming to our notice this year were purchased at average prices equal to Station's valuation, the cost of the three home mixtures was low; also, $1.50, rather than $3.81, may be considered as the average charge in these instances for the labor of mixing and re-bagging the special mixtures, it being assumed that the other expenses are the same in either case. The actual charge in the case of the individual transactions, which may be learned by an inspection of the table, will show the actual financial advantage gained by each individual from either home-mixing or special mixing to order. Of course, a further agricultural advantage is to be derived from the possibility of specifying the composition or formula, which pre-supposes a knowledge, on the part of the farmer, of the needs of his soil and crop. The possible saving by these methods is great; to secure it, the farmer must use business-like methods of purchase, based upon a knowledge of the state of the fertilizer market.

4.

THE EXAMINATION AND VALUATION OF MANUFACTURED BRANDS, MISCELLANEOUS PRODUCTS AND SUNDRY MATERIALS.

The object of this, the main fertilizer work of the Station, is to determine by chemical analysis whether the *actual* composition of each of the various manufactured products corresponds with its *guaranteed* composition, as required by law, whereby it is shown whether the material fulfills the claims of the manufacturer and to what degree the guarantee given is a guide to the amounts of plant-food delivered to the consumer. In addition, the application of the schedule of

page, gives relatively the manufacturing or first cost of the individual brands, which may be directly compared with the selling prices to show the charges of the manufacturer for mixing, bagging and other expenses in effecting their sale.

This work is of twofold value :—*direct*, in that it furnishes the shrewd and experienced purchaser with information as to the composition and cost of the brands to which his attention may he drawn ; and *indirect*, in its restraining influence, whereby worthless material is practically kept away from our markets.

1. Complete Fertilizers.

The 394 samples of complete fertilizers, the analyses of which are herewith reported, represent 391 distinct commerical brands, which is seventy-eight more than last year. Three brands appear in duplicate ; in each case the manufacturer claimed that the original sample did not represent the true character of the goods, and another sample was therefore examined ; as both samples represent large stocks, both analyses have been published. The 391 brands are the product of ninety-five establishments, if the branches of the American Agricultural Chemical Company be considered separately. There is, therefore, not only a greater number of manufacturers represented than last year, when the number was seventy-nine, but also a larger average representation. This amounts to about two additional brands for every ten manufacturers, so that the average representation per manufacturer is four and one-tenths brands this year, as compared with three and nine-tenths brands in 1901, and three and six-tenths brands in 1900. The average number of brands apiece, therefore, is over four ; there are sixty-five manufacturers each represented by this number or less, twenty by from five to eight (twice the average), seven by from nine to thirteen (three times the average), and three by from fourteen to eighteen (or four times the average). It is worthy of note, that eighty-four of the ninety-five manufacturers put on the market two-thirds of the number of brands with an average representation of three and one-tenths brands apiece.

Brand Names.

The extent to which multiplication of brands is in some cases carried would seem to be in excess of that needed for a range of choice, especially in those cases when the differences, to all practical

purposes, are in name only. It may be, however, that the market demands this, for it is undeniably true that with many fertilizer consumers the name still has considerable influence upon choice. This is all the more remarkable when we consider how many brand names carry no exact information in themselves, and when this is attempted how few manufacturers agree as to the proper formula for any specified crop. On the one hand, the names, "Harvest Queen" or "Farmer's Pride," in themselves give no information, and on the other, practically one-third of the great variety of brands examined this year are specially designated for potatoes.

A cursory examination of these will show that it is possible to select for potatoes brands which the manufacturers intend to contain (as shown by their guarantees of ammonia, available phosphoric acid and potash), 1, 6, 4 per cent., 2, 8, 10 per cent., 3, 8, 10 per cent., 4, 6, 10 per cent., 5½, 8, 8 per cent., 4, 9, 7 per cent., 3, 9, 4 per cent., 2, 10, 4 per cent., or 1, 4, 8 per cent. of these ingredients, or almost any other combination of figures. With a certain number of exceptions, the theory of special fertilization is so ignored that the same brands are designated not only for potatoes, but also for beans, cabbage, tobacco, hops, corn, general truck or general use, until it would seem that rational procedure would have been to cut out all but this last, and simply say "for general use."

For the purchaser, therefore, the necessity may readily be seen of the printed statement of analysis or guaranteed composition of each brand which is required by law, and the importance of a conformity of the actual composition with it.

Guarantees and Actual Composition.

Without exception, every brand examined this year has been accompanied by a guarantee, as the fertilizer law of New Jersey requires shall accompany all packages or lots of over one hundred pounds sold, offered or exposed for sale. It will be noticed in the tables, however, that in a little over one-half of the samples the guarantee of phosphoric acid is defective, either available or total phosphoric acid alone being guaranteed. The absence of guarantee of total in certain instances is commercially not of great importance when the available is given, since the surplus which goes to make up the total is insoluble and comparatively inexpensive. Agriculturally, however, when consumers scrutinize guarantees, in order to select brands in which the quickly-available phosphoric acid is accompanied by a

desired amount of the more slowly-available, the guarantee giving this information becomes of particular value. But when, on the other hand, total phosphoric acid alone is guaranteed, there is no information whatever afforded as to its availability—a very important matter in the choice of a fertilizer. Among the samples examined this year, there are twenty-two cases in which the latter is the case. In eight of these, no great amount of available should be expected, since they are intended as slowly-acting manures and consist of fish and potash, bone and potash, etc. In most of the others there is a fair amount of available, and the manufacturer is losing credit for good goods by not claiming it. As this may not always be the case, consumers should insist upon a complete compliance with the law before they consent to purchase.

A scrutiny of the analysis of each brand, and a careful comparison of its actual composition, with its accompanying guarantee, show that about 31 per cent. of them are deficient in one or more of the different forms of plant-food. The deficiencies, compared with those of the past seven years, are shown in the following table. In compiling this table, deficiences in nitrogen to the extent of 0.20 per cent., and in phosphoric acid and potash to the extent of 0.30 per cent, have been ignored :

YEAR.	Number of Brands.				Deficiencies possible.	Actual Deficiencies.			
	Examined.	Found as guaranteed.	Found deficient.	Percentage deficient.		Nitrogen.	Phosphoric Acid.	Potash.	Percentage.
1895	269	158	111	41	807	17	72	37	15.6
1896	329	211	118	36	987	30	52	56	14.0
1897	284	194	90	32	852	29	47	30	12.4
1898	303	201	102	34	909	48	29	49	13.3
1899	321	222	99	31	963	33	51	32	12.0
1900	298	214	84	29	894	33	35	31	11.1
1901	308	202	106	35	924	31	60	34	13.5
1902	391	269	122	31	1,173	44	54	49	12.5

As indicated in the table, there are 147 deficiencies distributed among 122 brands, nineteen brands being deficient in two particulars and three brands in all three particulars of their guarantees. As there is a total of 1,173 deficiences possible in the 391 brands examined, it follows, therefore, that 12½ per cent. of these possibilities have actually occurred. This percentage would be larger were it not for the allowance of 0.20 and 0.30 per cent. referred to, whereby many brands would be classed as deficient in more particulars than here stated.

The average valuation of those which do not meet their guarantees is $21.57, and of those which do, $21.21, and their average selling prices are $28.78 and $27.16, showing that the deficiencies do not occur in the low-priced or high-priced goods as a class. The differences between valuation and selling price, $7.21 and $5.95, however, show the financial advantage of buying only those goods which are up to guarantee, as the saving would on the average be equivalent to an immediate discount of 4 per cent. on the money invested.

Station's Valuations and Selling Prices.

The Station's valuation per ton is derived by applying to the different constituents the schedule of prices already given it; it is intended to show the retail cash cost of the amount of nitrogen, phosphoric acid and potash contained in one ton if they were bought at factory in the form of raw materials, unmixed. The difference between selling price and Station's value shows, therefore, the charge that is made for mixing, bagging, shipping and *selling* the several brands.

The selling price per ton entered in the table is the price at the point where sampled. These prices differ in the various localities of the State, due mainly to differences in freight rates from point of production to consumers' depot, the amount sold and commission charged. Nothing has been added to the valuations to represent these charges, the Station preferring to let the consumer make such calculations himself, whereby they will apply to his own conditions.

The average composition, estimated value and selling price of all of the brands of complete fertilizers examined each year for the past twelve years, together with the actual and the percentage difference by which the selling price exceeds the valuation, are shown in the following tabulation:

YEAR.	Total Nitrogen.	Total Phos. Acid.	Available Phos. Acid.	Insoluble Phos. Acid.	Potash.	Station's Valuation.	Selling price.	Actual difference.	Percentage difference.
1891	2.71	10.12	7.29	2.63	4.21	$25 31	$34 23	$8 92	35.2
1892	2.74	10.38	7.70	2.67	4.50	25 66	34 19	8 53	33.2
1893	2.69	10.23	7.54	2.69	4.58	24 41	34 11	9 70	39.7
1894	2.87	10.40	7.37	3.03	4.94	24 83	34 17	9 34	37.6
1895	2.80	10.74	7.84	2 90	4.80	24 15	32 87	8 72	36.1
1896	2.51	10.86	8.21	2.65	5.02	21 70	30 33	8 63	39.8
1897	2.54	10.93	8.01	2.91	5.01	21 58	29 28	7 70	35.7
1898	2.45	10.69	8.37	2.32	5.38	19 90	28 58	8 68	43.6
1899	2.41	10.58	8.27	2.31	5.67	19 95	27 75	7 80	39.1
1900	2.30	11.03	8.44	2.59	5.89	20 77	27 26	6 49	31.2
1901	2.31	10.48	8.08	2.40	5.77	21 19	27 31	6 12	28.9
1902	2.38	10.47	8.09	2.38	5.32	21 82	27 66	6 34	29.7

It will be observed that there has been a slight falling off in the average potash furnished, and a slight increase in the nitrogen and in the selling price. The advance in the cost of ammoniates last spring was met by increases in the Station's schedule, by which the valuations have been computed. It becomes of interest, therefore, to calculate the average valuation for the past two years by means of the same schedule. Using last year's schedule, the valuations, compared with the selling prices, are shown as follows:

	Station's Valuation.	Selling Price.	Actual Difference.
1901	$21 19	$27 81	$6 12
1902	21 06	27 66	6 60

It appears, therefore, that the manufacturers are delivering, on the average, somewhat less total plant-food than in 1901, at a slight advance per ton.

Taking the valuations and selling prices as they are, however, the average difference is $6.34, which represents the average charge of the entire number of manufacturers for mixing and bagging an average of about $21 worth of plant-food, and for dealers' commissions and other expenses incurred in effecting its sale and delivery. This is practically 30 per cent. of the value delivered; that this average charge is not made in all cases is apparent from an examination of the tables, where it will be found that sixty-four, or two-thirds of the manufacturers, are represented by brands which furnish plant-food at an advance ranging below 30 per cent.; twenty-eight from 30 to 60 per

cent. and three from 60 per cent. upwards, the highest price reaching 107 per cent. advance over the cost of an equal quantity of plant-food in the form of standard raw materials.

2. Ground Bone.

The twenty-six samples of ground bone examined this year are of good quality, and with a few exceptions were as guaranteed and sold at prices very close to Station's valuations. In composition the samples run from 1.28 to 4.87 per cent. of nitrogen, and from 20.80 to 29.64 per cent. of phosphoric acid. There is somewhat of a relation between the two, a high nitrogen content being usually accompanied by a low phosphoric acid, and *vice versa*, but this relation is not mathematically perfect. In the finest sample, 96 per cent. will pass a one-fiftieth-inch sieve, and in the coarsest only 33 per cent.

The average fineness and composition of the samples this year, as compared with 1899, 1900, and 1901, is shown as follows :

	Fine, Per Cent.	Coarse, Per Cent.	Nitrogen, Per Cent.	Phosphoric Acid, Per Cent.
Average for 1899..............	49	51	3.17	22.83
" " 1900..............	63	37	3.24	23.33
" " 1901..............	52	48	3.20	24.20
" " 1902..............	57	43	3.05	25.41

There was no change in the Station's schedule for the valuation of bone this year ; the average valuations for the past two years, therefore, may be directly compared with each other, and with the selling prices, as follows :

	Station's Value.	Selling Price.	Difference.
Average for 1901..................	$26 09	$28 98	$2 89
" " 1902..................	26 85	26 97	0 12

Average ground bone this year, therefore, valued a little higher and sold $2 cheaper than last year, so that the average advance over Station's valuation was only twelve cents a ton ; an inspection of the table of analyses, however, will show a few individual exceptions, as high a price as $35 being reported for a brand which valued at exactly $26.

3. Miscellaneous Fertilizers and Sundry Materials.

Of the twenty-eight samples of miscellaneous fertilizers, one is a duplicate sample, six are plain superphosphates, eighteen are plain superphosphates with potash, and three furnish phosphoric acid and nitrogen. In the case of nineteen of these materials, the brand name contains an allusion to bone. Purchasers of these materials should bear in mind that the presence of the word "bone" in the brand name means nothing whatever; true bone furnishes nitrogen and no water-soluble phosphoric acid, and when a material purports to be "animal bone," and does not conform to these requirements, it is not true bone. This is the case in all but two of the nineteen samples, the exceptions being in one case a true manipulated bone, and in the other a mixture of bone with acid phosphate. In calling attention to this, the Station does not intend to discriminate against the *use* of acid phosphate, of which most of these materials consist, but against the *purchase* of it as bone or at bone prices, which have been asked in three cases in particular.

All of the materials were accompanied by guarantees; these were fulfilled except in the case of six samples, which were low in their available. With a few exceptions these materials are expensive sources of plant-food. The acid phosphates, on the average, furnished available phosphoric acid at five and seven-tenths cents per pound, equal to $16 per ton for 14 per cent. available, whereas it is shown in an earlier portion of this report that acid phosphate of that availability has been purchased at an average of $11 per ton. The remaining samples, on the average, and excluding No. 2577, furnished plant-food worth at Station's valuations $13.68, for an average price of $19.20, an advance of $5.52, or over 40 per cent., whereas the average complete fertilizer only exceeds valuation by 30 per cent.

The sundry materials examined include four samples of wood ashes, one of lime kiln ashes and four of lime. While the first five contain phosphoric acid and potash, and one sample of prepared lime contains potash, the important feature in all of these materials is not only the presence but also the active form of the lime. The commercial value of this is dependent upon the price of lime in the neighborhood where it is desired; the Station's valuations are based only upon the phosphoric acid and potash at four and five cents per pound, respectively.

The remainder of the sundry materials are factory wastes, or natural products, which were examined to determine their character as sources of plant-food. They include three samples of tannery waste and one each of garbage ashes, oil-cake waste, wool waste, soot, bone residue, a so-called "unnamed" fertilizer, tobacco stems and a natural bat guano.

FORMS OF NITROGEN.

Readily and Completely Soluble in Water.

Station Number.	FROM WHOM RECEIVED.	Percentage of Nitrogen.	Cost of Nitrogen per lb.	Cost of 2,000 lbs. of Material.
	Nitrate of Soda.	%	cts.	
2023	J. S. Collins & Son, Moorestown	15.46	*15.52	$48 00
2107	S. L Pancoast, Mullica Hill	15.64	13.27	41 50
2130	W. Davis, Cedarville	14.22	*15.47	44 00
2171	H. Schnitzer, Fairton	15.42	14 50	45 00
2201	W. Saalman, Egg Harbor City	15.65	13.80	43 20
2218	College Farm	15.76	14.28	45 00
2251	Mixner & Mickel, Bridgeton	15.51	*17.73	55 00
2297	J. G Schanck, Keyport	15.49	*17.75	55 00
2527	J. W. Pincus, Woodbine	16.18	13.02	42 00
2756	J. Q. Holcombe, Ringoes	15.54	14.91	46 35
	Average Cost per Pound	....	13.98	

FORMS OF NITROGEN INSOLUBLE IN WATER.

Station Number.	FROM WHOM RECEIVED.	Percentage of Nitrogen.	Percentage of Phosphoric Acid.	Cost of Nitrogen per lb.	Cost of 2,000 lbs. of Material.
	Dried Blood.	%	%	cts.	
2219	College Farm	10.58	3.37	15.26	$35 00
2403	J. Y. Dilatush, Robbinsville	13.10	0 62	18.13	48 00
2575	J. B. Warwick, Hartford	12.75	0.00	15.69	40 00
	Average Cost per Pound			16.31	
	Dried and Ground Fish.				
2022	§ Hopkins & Lippincott, Moorestown	5.29	8.68	*19.00	23 00
2084	J. S. Collins & Son, Moorestown	8.56	6.88	17.47	35 00
2085	H. Clement, Woodbury	8.17	7.15	17.92	35 00
2086	" "	6.94	5.79	20.44	33 00
2087	† Henry Stanley, Westville	9.20	1.02	*17.49	33 00
2199	J. Hoenes, Cologne	7.18	6.00	19.78	33 00
2200	‡ " "	7.85	7.62	15.22	30 00
2202	W. Saalman, Egg Harbor City	8.77	6.10	10.15	33 20
2258	Mixner & Mickel, Bridgeton	9.04	5.05	17.12	35 00
2274	J. Strickland, Jackson's Mills	5.04	7.01	23.20	29 00
2633	F. H. Macfarland, Hammonton	7.82	5.92	17.43	32 00
2736	J. Q. Holcombe, Ringoes	8.63	5.40	17.31	35 00
	Average Cost per Pound			18.20	

* Not included in the average.

† King Crab.

‡ Unground.

§ Crude Fish.

FORMS OF NITROGEN INSOLUBLE IN WATER.

TANKAGE.

Station Number.	FROM WHOM RECEIVED.	MECHANICAL ANALYSIS.		PERCENTAGE.		Cost of 2,000 lbs. of Material.
		Finer than $\frac{1}{50}$ inch.	Coarser than $\frac{1}{50}$ inch.	Nitrogen.	Phosphoric Acid.	
2174	W. Wilde, Vineland	18	82	5.84	8.72	$26 00
2204	W. Saalman, Egg Harbor City	51	49	7.52	9.88	26 20
2220	College Farm	58	47	5.90	18.23	28 00
2252	Mixner & Mickel, Bridgeton	47	58	3.19	12.25	28 00
2348	H. H. Riggs, Hightstown	54	46	4.68	18.72	26 00
2402	J. Y. Dilatush, Robbinsville	32	66	6.72	9.58	25 00
2503	Ira Hill, Copper Hill	41	59	5.08	7.08	22 00
2504	" " " "	23	77	5.23	9.90	22 00

TANKAGE.

Station Number.		COST OF NITROGEN PER LB. IN— *		COST OF PHOSPHORIC ACID PER LB. IN—	
		Finer than $\frac{1}{50}$ inch.	Coarser than $\frac{1}{50}$ inch.	Finer than $\frac{1}{50}$ inch.	Coarser than $\frac{1}{50}$ inch.
		cts.	cts.	cts.	cts.
2174	Tankage	*23.28	*17.46	*5.82	*4.37
2204	"	15.12	11.34	3.78	2.84
2220	"	14.08	10.56	3 52	2 64
2252	"	*25.80	*19.35	*6.45	*4.83
2348	"	15.76	11.82	3.94	2.96
2402	"	16.52	12.39	4.13	3.10
2503	"	18.96	14.22	4.74	3.56
2504	"	17.68	13 26	4.42	3.31
	Average Cost per Pound	**16.35**	**12.26**	**4.09**	**3.07**

* Not included in the average.

PLAIN SUPERPHOSPHATES.

Furnishing Soluble, Reverted and Insoluble Phosphoric Acid.

Station Number	FROM WHOM RECEIVED.	PHOSPHORIC ACID. Soluble in Water.	PHOSPHORIC ACID. Soluble in Ammonium Citrate.	PHOSPHORIC ACID. Insoluble.	PHOSPHORIC ACID. Available.	Cost of Available Phosphoric Acid per lb.	Cost of 2,000 lbs. of Material.
		%	%	%	%	cts	
2010	L. Collins, Moorestown	10.76	2.45	1.89	13.21	3.78	$10 00
2017	G. W. Jessup, Moorestown	11.76	3.14	1.62	14.90	2.77	8 25
2173	W. Wilde, Vineland	10.86	3.64	1.67	14.50	4.14	12 00
2208	W Saalman, Egg Harbor City	10.70	4.11	1.60	14.81	3.61	10 70
2221	College Farm	11.32	2.74	3.98	14.06	3.50	10 00
2254	Mixner & Mickel, Bridgeton	10.82	2.67	3.79	13.49	4.45	12 00
2347	H. H. Riggs, Hightstown	11.38	2.59	2.40	13.97	4.29	12 00
2528	J. W. Pincus, Woodbine	10.68	3.36	1.80	14.04	3.33	9 35
2787	J. Q. Holcombe Ringoes	12.04	1.83	0.09	13.87	3.66	10 15
2548	*J. A. Shafer, Milford*	*8.24*	*4.68*	*2.18*	*12.92*	**5.80*	*15 00*
2701	P. S Yetter, Belvidere	12.90	3.28	2.28	16.18	4.33	14 00
2742	J. Prall, Flemington	10.20	2.78	3.47	12.98	4.62	12 00
2552	L. Shurts, Neshanic Station	12.10	2.38	2.61	14.48	4.50	13 00
	Average Cost per Pound					3.92	

* Not included in the average.

GERMAN POTASH SALTS.

Station Number.	FROM WHOM RECEIVED.	Percentage of Potash.	Cost of Potash per lb.	Cost of 2,000 lbs. of Material.
	Muriate of Potash.	%	cts.	
2006	A. A. Bennett, Cranbury	51.81	3.70	$38 00
2108	S. L. Pancoast, Mullica Hill	50.17	4.13	41 50
2131	*W. Davis, Cedarville*	*55.15*	*3.90*	*43 00*
2172	W. Wilde, Vineland	50.97	4.12	42 00
2229	College Farm	49.86	4.01	40 00
2255	Mixner & Mickel, Bridgeton	53.35	4.22	45 00
2505	Ira Hill, Copper Hill	50.49	4.16	42 00
2580	J. W. Pincus, Woodbine	46.39	4.20	39 00
2738	J. Q. Holcombe Ringoes	48.44	4.13	40 00
2702	P. S. Yetter, Belvidere	51.44	4.37	45 00
2749	Mundy Bros., Bound Brook	46.76	4.64	43 40
	Average Cost per Pound		4.14	
	High Grade Sulphate of Potash.			
2529	J. W. Pincus, Woodbine	43.62	5.04	44 00
	Kainit.			
2057	Taylor Bros, Camden	12.83	4.87	12 50
2256	Mixner & Mickel, Bridgeton	12.71	4.72	12 00
	Average Cost per Pound		4.80	

Home Mixtures and Special Compounds

Furnishing Nitrogen, Phosphoric Acid and Potash.

MANUFACTURER AND BRAND.	WHERE SAMPLED.	Station Number.
HOME MIXTURES.		
J. H. Higgins, Barley Sheaf	Barley Sheaf	1687
L. E. Savacool, Newton	Newton	2724
J. B. Warwick, Hartford (Moorestown Grange)	Hartford	2576
SPECIAL COMPOUNDS.		
The Nassau Fertilizer Co., New York City.		
Pomona Grange Mixture No. 1	Harmony	2745
" " " No. 2	"	2746
Newport Fertilizer Co., Philadelphia, Pa.		
Coffin Brand	Ashland	2052
Gloucester County Grange Sweet Potato Fertilizer	Swedesboro	2399
" " " White Potato Fertilizer	"	2400
Egan's Formula	Moorestown	2350
Hilton Brand	Hartford	2033
Pomona Grange Potato Mixture	Harmony	2345
" " Grain Mixture	"	2346
Somerset Chemical Co., Bound Brook, N. J.		
Amerman's No. 2 Special	Neshanic	1682
" No. 3 "	"	1683
I. P. Thomas & Son Co., Philadelphia, Pa.		
Roxburg Grange Mixture	Brainards	1681
Trenton Bone Fertilizer Co., Trenton, N. J.		
Silvers & Hutton Brand	Cranbury	2374
Williams & Clark Branch, New York City.		
Blawenburg Grange No. 1	Blawenburg	1678
" " No. 3	"	1679
Grand View Grange Mixture No. 1	Flemington	2740
" " " " No. 2	"	2741
Millstone Grange Mixture No. 1	Millstone	2476
" " " No. 2	"	2477
" " " No. 4	"	2478

Home Mixtures and Special Compounds

Furnishing Nitrogen, Phosphoric Acid and Potash.

Nitrogen.					Phosphoric Acid.							Potash.		Value of 2,000 lbs. at Station's Prices.	Selling Price of 2,000 lbs. at Consumers' Depot.
										Available.					
From Nitrates.	From Ammonia Salts.	From Organic Matter.	Total Found.	Total Guaranteed.	Soluble in Water.	Soluble in Ammonium Citrate.	Insoluble.	Total Found.	Total Guaranteed.	Found.	Guaranteed.	Found.	Guaranteed.		
......	......	1.08	1.03	......	4.96	6.36	4.95	16.27	....	11.32	....	6.54	....	†$22 18	$20 37
0.88	......	2.06	2.89	3.28	8.34	6.18	1.40	10.92	....	9.52	8.50	12.87	12.00	30 31	28 00
1.18	0.82	1.27	3.22	......	2.52	9.26	2.33	14.11	....	11.78	....	9.88	....	31 40	25 50
0.40	......	1.72	2.12	2.05	4.00	4.12	2.42	10.54	9.00	8.12	8.00	6.48	6.00	21 48	19 75
......	......	1.18	1.13	0.82	3.88	4.76	2.40	11.04	10.00	8.64	9.00	3.17	3.00	16 13	14 60
0.81	......	1.28	2.09	2.46	4.28	1.89	3.17	9.34	....	6.17	6.00	*9.74	12.00	23 83	32 00
......	......	1.87	1.87	2.05	7.26	1.66	2.91	11.83	......	8.92	6.00	9.05	10.00	23 94	23 61
0.61	0.95	1.46	3.02	3.49	6.88	2.07	2.80	11.75	10.00	8.95	6.00	8.39	8.75	26 99	26 00
1.79	......	3.54	5.33	3.69	6.16	3.79	0.75	10.70	....	9.95	7.00	11.50	10.00	36 91	31 85
1.21	......	1.64	2.85	3.29	4.04	1.81	2.78	8.63	....	5.85	7.00	10.45	10.00	24 88	29 00
0.77	......	1.28	2.00	2.46	6.88	1.59	2.73	11.20	....	8.47	7.50	*6.00	8.00	21 76	24 10
1.28	......	0.82	3.10	2.46	7.26	2.03	3.34	12.63	....	9.29	9.00	*2.51	2.00	19 26	19 55
0.58	......	1.25	1.83	1.64	0.00	7.26	3.57	10.83	....	7.26	8.00	4.25	5.00	†17 98	25 00
......	......	0.85	0.85	0.82	0.02	6.63	3.74	10.39	....	6.65	10.00	3.58	4.00	†13 92	20 00
......	......	2.15	2.15	2.50	5.18	4.21	2.82	12.21	....	9.39	8.00	4.59	6.00	†21 30	19 00
1.47	......	2.68	4.15	4.10	3.56	5.08	1.78	10.37	....	8.64	8.00	10.08	10.00	31 15	35 00
0.17	0.26	0.57	1.00	0.82	6.04	3.64	2.07	11.75	10.00	9.68	9.00	7.11	7.00	†19 72	19 25
0.44	0.39	1.27	2.10	2.05	1.92	5.71	3.15	10.78	....	7.63	8.00	6.03	6.00	†20 65	22 40
......	......	2.27	2.27	1.64	2.82	5.15	3.09	11.06	9.00	7.97	8.00	10.34	10.00	26 23	26 00
......	0.46	2.19	2.65	1.23	2.12	4.35	2.63	9.10	7.00	6.47	6.00	6.16	6.00	21 51	23 00
......	......	1.69	1.69	1.23	1.82	5.42	2.82	10.06	....	7.24	8.00	4.92	5.00	18 15	20 00
0.40	0.92	0.75	2.07	2.46	4.02	3.47	1.61	9.00	....	7.49	6.00	9.07	10.00	22 53	25 00
0.87	0.97	1.46	3.30	2.46	3.90	3.73	2.64	10.27	....	7.63	8.00	7.98	8.00	26 10	28 00

*Potash largely, if not entirely, in form of sulphate. † 1901 valuation.

Complete Fertilizers

Furnishing Nitrogen, Phosphoric Acid and Potash.

MANUFACTURER AND BRAND.	WHERE SAMPLED.	Station Number.
J. H. Allen & Son, Lawrence Station, N. J.		
Bone and Potash	Lawrence Station	2452
Complete Phosphate	" "	2458
Potato and Truck Manure	" "	2620
American Agricultural Chemical Co., New York City.		
Bradley Branch.		
New Method Fertilizer	Keyport	2306
Potato Fertilizer	Belvidere	2710
Complete Manure for Potatoes and Vegetables	Freehold	2323
Complete Manure with 10 Per Cent. Potash	*Keyport*	2306
Potato Manure	Roselle	2647
Bean and Potato Phosphate	"	2648
Niagara Phosphate	Afton	2688
Chicopee Guano Branch.		
A 1 Vegetable and Potato Manure	Cold Spring	2228
Special New Jersey Brand	Lyons Farms	2650
Standard Guano	" "	2651
Farmers' Reliable	Westwood	2665
Clark's Cove Branch.		
Fish and Potash	Keyport	2309
Great Planet	Plainsboro	2621
Crocker Branch.		
Wheat and Corn Fertilizer	Paterson	2690
Cabbage and Potato Manure	Turkey	2328
Special Potato Manure	Holmdel	2357
Harvest Jewel Fertilizer	Paterson	2691
East India Branch.		
Baker's Complete Manure for General Use	West Long Branch	2310
" Potato Manure	Marlboro	2358
" Turnip Manure	Red Bank	2318
" "AA" Ammoniated Superphosphate	" "	2314
" Standard UNXLD Fertilizer	Plainsboro	2622
" *Harvest Home Phosphate*	*Morristown*	2698
Great Eastern Branch.		
Vegetable, Vine and Tobacco	Blackwood	2050
Garden Special	"	2051
Northern Corn Special	Princeton Junction	2456
General	Basking Ridge	2584
Wheat Special	" "	2580

Complete Fertilizers

Furnishing Nitrogen, Phosphoric Acid and Potash.

Nitrogen.					Phosphoric Acid.							Potash.		Value of 2,000 lbs. at Station's Prices.	Selling Price of 2,000 lbs. at Consumers' Depot.
From Nitrates.	From Ammonia Salts.	From Organic Matter.	Total Found.	Total Guaranteed.	Soluble in Water.	Soluble in Ammonium Citrate.	Insoluble.	Total Found.	Total Guaranteed.	Available. Found.	Available. Guaranteed.	Found.	Guaranteed.		
......	......	3.23	3.33	2.46	0.04	9.23	7.22	16.49	15.75	9.27	....	3.28	3.00	$25 61	$25 00
0.74	......	1.82	2.56	2.46	4.52	5.83	2.88	13.23	11.00	10.35	8.00	2.09	2.00	21 52	25 00
0.87	......	2.66	3.53	3.28	4.60	3.74	2.18	10.47	10.00	8.34	7.00	10.29	10.00	29 33	32 00
......	......	0.99	0.99	0.82	4.68	3.78	1.84	10.30	9.00	8.46	8.00	2.25	2.00	14 38	21 00
......	......	2.21	2.21	2.05	3.96	4.87	2.52	11.35	9.00	8.83	8.00	3.33	3.00	19 96	25 00
0.82	0.88	1.85	3.55	3.28	2.12	5.60	3.44	11.16	9.00	7.72	8.00	7.36	7.00	26 83	29 00
......	1.48	1.78	3.26	3.28	3.70	2.12	1.34	7.16	7.00	5.82	6.00	10.59	10.00	26 11	32 50
0.76	......	1.66	2.42	2.46	1.64	3.97	3.91	9.52	7.00	5.61	6.00	*6.98	6.00	21 02	35 00
......	......	0.88	0.88	0.82	5.70	2.62	1.95	10.27	9.00	8.32	8.00	4.39	4.00	15 73	28 00
......	......	0.98	0.98	0.82	4.30	2.76	2.00	9.06	8.00	7.06	7.00	1.46	1.00	12 33	22 00
0.69	......	1.63	2.32	2.46	4.12	3.99	1.94	10.05	9.00	8.11	8.00	6.02	6.00	21 46	25 00
......	0.66	2.00	2.66	2.46	5.30	1.51	1.71	8.52	7.00	6.81	6.00	10.32	10.00	25 04	32 50
......	......	1.06	1.08	0.82	6.82	1.98	2.52	10.82	8.00	8.30	8.00	5.21	4.00	17 30	24 00
......	......	0.98	0.98	0.82	5.46	2.51	2.61	10.58	8.00	7.97	7.00	1.69	1.00	13 68	21 00
......	0.22	2.06	2.28	1.64	4.32	3.44	3.02	10.78	9.00	7.76	8.00	2.26	2.00	18 42	24 00
0.58	0.81	1.80	3.19	3.28	5.94	2.82	1.66	9.82	9.00	8.26	8.00	7.13	7.00	25 29	31 00
......	......	2.24	2.24	2.05	6.54	1.97	2.66	11.17	9.00	8.51	8.00	2.30	1.50	18 92	24 00
......	0.51	2.02	2.53	2.46	6.62	1.66	2.10	10.38	9.00	8.28	8.00	6.47	6.00	22 97	28 00
0.41	0.68	1.61	2.70	3.28	7.04	1.53	1.72	10.29	9.00	8.57	8.00	7.78	7.00	24 65	30 00
0.24	0.27	1.28	1.74	1.64	5.90	1.94	2.23	10.07	9.00	7.84	8.00	2.86	2.00	16 83	22 00
......	0.97	1.42	2.39	2.46	3.54	4.16	2.51	10.21	9.00	7.70	8.00	5.71	6.00	21 44	31 00
......	1.50	1.96	3.46	3.28	3.82	1.88	1.55	7.25	7.00	5.70	6.00	10.45	10.00	26 62	34 00
......	2.01	3.36	5.37	5.74	3.76	1.61	2.22	7.59	6.00	5.37	5.00	8.91	9.00	31 55	40 00
......	0.98	1.69	2.67	2.46	6.36	2.97	1.84	11.17	11.00	9.33	9.00	2.33	2.00	20 90	30 00
0.43	......	1.91	2.34	2.05	4.16	3.68	3.20	11.04	9.00	7.84	8.00	3.29	3.00	19 51	26 00
......	......	1.31	1.31	1.03	3.04	4.86	3.30	11.20	9.00	7.90	8.00	2.02	2.00	15 26	25 00
......	0.40	1.61	2.01	2.05	5.60	2.57	1.23	9.40	9.00	8.17	8.00	3.18	3.00	17 99	25 00
......	1.24	2.02	3.26	3.28	5.56	2.70	1.71	9.97	9.00	8.26	8.00	6.76	7.00	25 44	33 00
......	0.45	2.14	2.59	2.46	4.88	3.99	2.43	10.80	11.00	8.37	9.00	2.10	2.00	19 68	26 00
......	......	1.00	1.00	0.82	7.24	2.89	1.97	12.10	9.00	10.13	8.00	4.17	4.00	17 77	25 00
......	......	1.85	1.85	1.64	7.14	2.34	2.40	11.88	9.00	9.48	8.00	2.48	2.00	16 66	24 00

* Potash largely, if not entirely, in form of sulphate.

Complete Fertilizers

Furnishing Nitrogen, Phosphoric Acid and Potash.

MANUFACTURER AND BRAND.	WHERE SAMPLED.	Station Number.
American Agricultural Chemical Co.—(Cont.)		
Milsom Branch.		
Blood, Bone and Potash Fertilizer	Cranbury	2388
Buffalo Guano	Paterson	2696
Potato, Hop and Tobacco Fertilizer	"	2697
Vegetable Bone Fertilizer	Stillwater	2780
Corn Fertilizer	Newton	2781
Pacific Guano Branch.		
Special Potato Manure	Hightstown	2392
Nobsque Guano	"	2393
Potato Phosphate	"	2394
A No. 1 Phosphate	Millington	2590
Ammoniated Dissolved Bone	Martinville	2589
Packers' Union Branch.		
Gardeners' Complete Manure	Mt. Ephraim	2056
Potato Manure	" "	2058
Universal Fertilizer	Elizabeth	2659
Animal Corn Fertilizer	Hopewell	2444
Moro Phillips Branch.		
Fish Guano	Westville	2101
New Jersey Potato Manure	Cold Spring	2287
Special Fertilizer	Fishing Creek	2286
C. and G. Complete Fertilizer	Cold Spring	2288
Preston Branch.		
Ammoniated Superphosphate	Egg Harbor City	2209
Potato and Onion Fertilizer	Hamburg	2782
Corn Fertilizer	Freehold	2842
Corn Guano	"	2843
XXV Fertilizer	Fairmount	2566
Read Branch.		
Vegetable and Vine Fertilizer	Florence	2034
Potato Manure	Prospect Plains	2866
Farmers' Friend	Pomona	2213
Bone, Fish and Potash	"	2212
Leader Blood and Bone	Three Bridges	2549
Standard Superphosphate	Englishtown	2870
High-Grade Farmers' Friend	Prospect Plains	2867
Practical Potato Special	Three Bridges	2550
Truck Fertilizer	Blairstown	2719

Complete Fertilizers

Furnishing Nitrogen, Phosphoric Acid and Potash.

Nitrogen. From Nitrates.	Nitrogen. From Ammonia Salts.	Nitrogen. From Organic Matter.	Nitrogen. Total Found.	Nitrogen. Total Guaranteed.	Phosphoric Acid. Soluble in Water.	Phosphoric Acid. Soluble in Ammonium Citrate.	Phosphoric Acid. Insoluble.	Phosphoric Acid. Total Found.	Phosphoric Acid. Total Guaranteed.	Phosphoric Acid. Available. Found.	Phosphoric Acid. Available. Guaranteed.	Potash. Found.	Potash. Guaranteed.	Value of 2,000 lbs. at Station's Prices.	Selling Price of 2,000 lbs. at Consumers' Depot.
0.58	0.50	2.85	3.38	3.28	5.04	2.39	1.84	9.27	7.00	7.43	6.00	10.16	10.00	$27 81	$29 00
......	......	1.21	1.21	0.82	4.76	3.34	1.66	9.76	9.00	8.10	8.00	4.28	4.00	16 37	24 00
......	......	2.28	2.28	2.05	3.98	4.29	2.64	10.91	9.00	8.27	8.00	3.37	3.00	19 72	26 00
0.70	......	2.80	3.50	3.38	4.58	3.51	2.18	10.27	9.00	8.09	9.00	7.27	7.00	26 48	30 00
......	0.97	1.56	2.53	2.46	6.52	3.00	2.02	11.54	11.00	9.52	9.00	2.30	2.00	20 64	22 00
......	......	2.52	2.52	2.46	3.38	2.86	2.74	8.98	7.00	6.24	6.00	7.39	6.00	21 94	32 00
......	......	1.20	1.20	1.03	4.42	3.93	2.15	10.50	9.00	8.35	8.00	2.48	2.00	16 28	22 00
......	......	1.64	1.64	1.23	2.30	3.74	3.61	9.65	7.00	6.04	6.00	5.05	5.00	17 18	25 00
......	......	1.11	1.11	0.82	2.00	4.29	*3.07	9.36	8.00	6.29	7.00	1.40	1.00	12 37	18 00
......	......	1.78	1.73	1.64	5.28	2.79	2.59	10.66	9.00	8.07	9.00	2.12	2.00	16 62	21 00
0.21	0.96	2.01	3.18	3.28	4.14	2.73	0.75	7.62	7.00	6.87	6.00	10.61	10.00	26 62	32 00
0.26	0.86	1.60	2.12	2.05	6.04	3.00	1.55	10.59	9.00	9.04	8.00	6.49	6.00	22 25	27 00
......	......	1.14	1.14	0.82	6.08	2.34	2.61	11.03	9.00	8.42	8.00	4.57	4.00	17 11	23 00
0.48	......	1.96	2.44	2.46	7.96	2.24	1.77	11.97	11.00	10.20	9.00	2.90	2.00	21 29	24 00
0.34	......	1.45	1.79	1.85	1.02	3.65	1.44	6.11	6.00	4.67	5.00	1.41	1.00	12 26	19 00
......	0.47	1.18	1.60	1.64	5.98	2.10	1.16	9.24	9.00	8.08	8.00	10.22	10.00	22 51	29 00
......	0.42	1.70	2.12	2.05	5.96	2.24	1.02	9.22	9.00	8.20	8.00	3.19	3.00	18 32	18 50
......	......	0.87	0.87	0.82	5.50	2.89	1.88	9.77	9.00	8.39	8.00	2.33	2.00	13 79	19 00
......	0.44	1.94	2.38	2.46	4.82	3.85	2.36	11.03	11.00	8.67	8.00	2.18	2.00	19 31	25 00
......	......	2.54	2.54	2.46	3.96	2.54	2.13	8.63	7.00	6.50	6.00	6.38	6.00	21 15	29 00
......	1.00	1.53	2.53	2.46	4.56	3.30	2.11	9.97	9.00	7.86	8.00	*6.54	6.00	22 77	26 00
......	......	2.24	2.24	1.64	3.50	4.42	3.28	11.20	9.00	7.92	8.00	3.22	3.00	19 38	21 00
......	......	1.26	1.26	0.82	5.36	1.98	2.32	9.66	8.00	7.34	7.00	1.48	1.00	13 69	19 00
......	0.41	1.52	1.93	2.05	6.80	2.04	1.38	9.72	9.00	8.34	8.00	6.66	6.00	20 07	28 00
......	0.71	1.83	2.54	2.46	5.06	1.13	1.63	8.02	7.00	6.19	6.00	10.40	10.00	24 14	31 00
......	0.36	1.72	2.08	2.05	6.18	1.86	1.74	9.78	9.00	8.04	8.00	2.99	3.00	19 15	26 00
......	0.49	1.90	2.39	2.46	3.52	2.94	1.78	8.04	7.00	6.26	6.00	6.79	6.00	19 78	28 00
......	......	0.90	0.90	0.82	4.00	2.29	2.68	8.97	8.00	6.29	7.00	1.27	1.00	11 41	21 00
......	......	1.02	1.02	0.82	7.06	1.75	2.50	11.31	9.00	8.81	8.00	4.54	4.00	17 04	22 00
0.48	0.51	2.37	3.36	3.28	4.76	1.85	2.34	8.95	7.00	6.61	6.00	10.02	10.00	27 01	33 00
......	......	1.32	1.32	0.82	4.94	1.96	2.37	9.27	5.00	6.90	4.00	6.94	8.00	17 34	29 00
0.48	0.56	1.77	2.81	3.28	6.54	1.57	1.96	10.07	9.00	8.11	8.00	6.76	7.00	23 77	34 00

* Potash largely, if not entirely, in form of sulphate.

Complete Fertilizers

Furnishing Nitrogen, Phosphoric Acid and Potash.

MANUFACTURER AND BRAND.	WHERE SAMPLED.	Station Number.
American Agricultural Chemical Co. (Cont.)		
Sharpless & Carpenter Branch.		
Soluble Tampico Guano	Fishing Creek	2241
Farmers' Improved Potato Manure	Medford	2076
Gilt Edge Potato and Tobacco Manure	Cedarville	2149
No. 1 Bone Phosphate	"	2150
Susquehanna Branch.		
Ammoniated Bone Phosphate	Hope	2722
Potato Phosphate	"	2723
Tygert-Allen Branch.		
Ten Per Cent. Guano	Collingswood	2080
Star Bone Phosphate	Cedarville	2156
Peerless Potato Manure	Bridgeton	2270
Fish, Bone and Potash	Pleasantville	2244
Special Brand Potato Manure	"	2245
Howitz's Potato Fertilizer	Jackson's Mills	2250
Star Guano	Bridgeton	2271
Truckers' Triumph Potato Guano	Jackson's Mills	2292
Nitro Phosphate	Mt. Holly	2429
Wheeler Branch.		
Potato Manure	Sewell	2105
Sweet Potato Manure	Swedesboro	2294
Corn Fertilizer	Cape May City	2247
Royal Wheat Grower	" " "	2249
Williams & Clark Branch.		
High-Grade Special Fertilizer	Dayton	2629
Royal Bone Phosphate	"	2628
Americus Universal Ammoniated Dissolved Bone	River Vale	2679
Good Grower Potato Phosphate	Martinville	2595
Potato Phosphate	Rahway	2660
Prolific Fertilizer	Millstone	2618
Americus Fertilizer	Dayton	2680
Armour Fertilizer Works, Baltimore, Md.		
Bone, Blood and Potash	Cranbury	2577
Grain Grower	Hackettstown	2705
Wheat, Corn and Oat Special	Califon	2565
Ammoniated Bone with Potash	Bound Brook	2599
Fruit and Root Crop Special	Hackensack	2662
High-Grade Potato	"	[illegible]

Complete Fertilizers

Furnishing Nitrogen, Phosphoric Acid and Potash.

Nitrogen.					Phosphoric Acid.							Potash.			
										Available.					
From Nitrates.	From Ammonia Salts.	From Organic Matter.	Total Found.	Total Guaranteed.	Soluble in Water.	Soluble in Ammonium Citrate.	Insoluble.	Total Found.	Total Guaranteed.	Found.	Guaranteed.	Found.	Guaranteed.	Value of 2,000 lbs. at Station's Prices.	Selling Price of 2,000 lbs. at Consumers' Depot.
......	1.37	1.78	3.15	3.28	5.68	2.52	1.58	9.78	9.00	8.20	8.00	7.50	7.00	$25 60	$36 25
0.47	1.08	1.78	3.23	3.28	4.70	2.23	0.91	7.84	7.00	6.93	6.00	10.04	10.00	26 34	28 00
......	0.20	1.32	1.52	1.64	6.58	2.02	1.10	9.70	9.00	8.60	8.00	9.82	10.00	22 41	28 00
......	......	1.73	1.73	1.64	4.46	3.09	1.76	9.31	9.00	7.55	8.00	1.90	2.00	15 58	22 00
0.24	......	1.68	1.92	1.64	6.00	2.35	2.51	10.86	9.00	8.35	8.00	2.14	2.00	17 43	27 00
......	......	1.48	1.48	1.64	6.70	1.89	1.82	10.41	9.00	8.59	8.00	6.54	6.00	18 91	28 00
1.75	2.89	2.86	7.50	8.20	2.90	2.62	0.75	6.27	6.00	5.52	4.00	4.02	4.00	33 47	45 00
......	0.25	1.76	2.01	2.05	5.58	2.77	1.40	9.75	9.00	8.35	8.00	3.03	3.00	18 12	23 00
......	0.32	1.32	1.64	1.64	5.78	2.14	1.26	9.18	9.00	7.92	8.00	9.53	10.00	21 94	28 00
......	0.46	1.90	2.36	2.46	4.32	3.71	2.64	10.67	11.00	8.03	9.00	2.17	3.00	18 71	28 00
0.47	......	1.51	1.98	2.05	6.48	2.58	1.59	10.60	9.00	9.01	8.00	5.69	6.00	20 88	28 00
......	......	1.28	1.28	1.23	2.34	3.42	1.66	7.42	7.00	5.76	6.00	5.00	5.00	14 89	23 00
......	0.45	1.58	2.03	2.05	8.65	3.69	2.74	10.31	9.00	7.57	8.00	3.37	3.05	18 24	25 00
......	1.30	1.97	3.27	3.28	2.28	3.76	1.65	7.69	7.00	6.04	6.00	9.63	10.00	25 68	32 00
......	0.46	1.72	2.18	2.05	2.56	5.23	3.02	10.81	9.00	7.79	8.00	3.34	3.00	19 04	25 00
......	0.36	1.74	2.10	2.05	5.88	2.08	1.72	9.68	8.00	7.96	8.00	3.15	3.00	18 26	25 00
0.25	0.29	1.44	1.98	2.05	6.70	2.27	1.65	10.62	9.00	8.97	8.00	5.89	6.00	21 10	27 00
......	....	1.67	1.67	1.64	5.16	2.61	2.13	9.90	9.00	7.77	8.00	2.06	2.00	15 88	26 00
......	.....	0.95	0.95	0.82	4.34	3.09	1.80	9.23	9.00	7.43	8.00	3.11	2.00	13 88	21 00
0.70	......	2.75	3.45	3.28	5.86	2.81	1.62	10.29	9.00	8.67	8.00	7.44	7.00	26 82	32 00
0.19	0.32	0.77	1.28	1.05	2.74	4.87	3.74	11.35	9.00	7.61	8.00	2.73	2.00	15 60	25 00
......	0.20	1.60	1.80	1.64	4 94	3.24	3.55	11.73	9.00	8.18	8.00	2.14	2.00	17 36	24 00
......	......	1.68	1.68	0.82	1.76	3.98	3.04	8.78	7.00	5.74	6.00	5.72	4.00	17 36	24 00
0.78	0.81	1.04	2.63	2.46	2.98	3.04	2.09	8.11	7.00	6.02	6.00	6.66	6.00	20 96	32 00
......	.....	1.14	1.14	0.82	2.72	4.16	2.64	9.52	8.00	6.88	7.00	1.40	1.00	13 89	20 00
0.21	0.89	2.13	2.73	2.46	5.40	3.62	3.00	12.02	11.00	9.02	9.00	2.28	2.00	21 11	28 00
0.24	.....	3.09	3.33	4.10	7.64	1.86	1.08	10.58	10.00	9.50	8.00	6.64	7.00	26 49	32 00
......	.....	1.57	1.57	1.64	6.98	1.20	0.99	9.17	10.00	8.18	8.00	2.56	2.00	15 94	25 00
......	......	1.14	1.14	0.82	5.38	1.69	0.99	8.06	9.00	7.07	7.00	1.98	1.00	12 27	21 00
......	.....	2.64	2.64	2.46	5.36	1.52	0.91	7.79	8.00	6.88	6.00	2.16	2.00	17 79	25 00
......	.....	1.72	1.72	1.64	7.30	1.12	0.56	8.98	10.00	8.42	8.00	5.20	5.00	18 74	33 00
......	.....	1.71	1.71	1.64	7.00	2.16	1 02	10.18	10.00	9.16	8.00	*10.24	10.00	24 39	35 00

* Potash largely, if not entirely, in form of sulphate.

Complete Fertilizers

Furnishing Nitrogen, Phosphoric Acid and Potash.

MANUFACTURER AND BRAND.	WHERE SAMPLED.	Station Number.
Warren Atkinson, Mullica Hill, N. J.		
High-Grade Potato and Early Truck Fertilizer	Mullica Hill	2109
Potato and General Truck	"	2110
Special Sweet Potato Fertilizer	"	2111
Cabbage and Tomato Manure	"	2276
Special Early Tomato Grower	"	2275
J. H. B ird, Marlboro, N. J.		
Potato Manure	Marlboro	2351
Asparagus Manure	"	2352
Grass Manure	"	2359
Baugh & Sons' Co., Philadelphia, Pa.		
$25 Phosphate	Woodstown	2112
Special Potato Manure	Mount Holly	2406
The Berg Co., Philadelphia, Pa.		
Lymph Guano for All Crops	Medford	2059
$25 Special Bone Manure	Belvidere	2709
Standard Bone Manure	Hammonton	2175
$35 Potato Manure	Cologne	2205
Berger Bros., Easton, Pa.		
Potato and Truck	Phillipsburg	2706
Peerless Phosphate	"	2707
Bowker Fertilizer Co., Boston, Mass.		
Stockbridge Potato and Vegetable Manure	Branchville	2726
Stockbridge Top Dressing	Bennett's Mills	2277
Stockbridge Corn Manure	River Edge	2664
Early Potato Manure	Sewell	2090
Potato and Vegetable Fertilizer	Bridgeton	2194
Farm and Garden Phosphate	Blackwood	2046
Potash-Bone	Paterson	2687
Sweet Potato and Truck Manure	Swedesboro	2278
Bone and Wood-Ash Fertilizer	Red Bank	2298
Hill and Drill Phosphate	"	2299
Sure Crop Phosphate	Pittstown	2581
Bone and Potash, Square Brand	Millstone	2601
Potash, or Staple Phosphate	Pennington	2480
Lawn and Garden Dressing	Plainfield	2642
Fish and Potash, Square Brand	"	2643
Ammoniated Dissolved Bone	Montclair	2645
Corn Phosphate	Whippany	2584
Six Per Cent. Potato Fertilizer	Morristown	2686

Complete Fertilizers

Furnishing Nitrogen, Phosphoric Acid and Potash.

Nitrogen. From Nitrates.	Nitrogen. From Ammonia Salts.	Nitrogen. From Organic Matter.	Nitrogen. Total Found.	Nitrogen. Total Guaranteed.	Phosphoric Acid. Soluble in Water.	Phosphoric Acid. Soluble in Ammonium Citrate.	Phosphoric Acid. Insoluble.	Phosphoric Acid. Total Found.	Phosphoric Acid. Total Guaranteed.	Phosphoric Acid. Available. Found.	Phosphoric Acid. Available. Guaranteed.	Potash. Found.	Potash. Guaranteed.	Value of 2,000 lbs. at Station's Prices.	Selling Price of 2,000 lbs. at Consumers' Depot.
0.78	0.91	1.92	3.61	3.69	6.72	3.28	1.55	11.55	11.00	10.00	9.00	*8.09	7.00	$29 18	$31 00
1.28	1.44	1.21	3.88	2.46	6.26	1.35	1.98	9.61	10.00	7.63	7.00	6.94	7.00	26 75	27 00
......	......	1.90	1.90	1.64	4.50	3.74	3.36	11.60	10.00	8.24	8.00	10.64	10.00	24 89	27 00
0.67	......	1.95	2.62	2.46	4.66	3.66	3.46	11.78	9.00	8.32	7.00	6.40	5.00	23 59	26 00
1.91	......	3.16	5.07	4.92	5.72	2.04	1.04	8.80	8.00	7.76	7.00	4.85	4.00	28 46	33 00
1.06	1.84	1.81	3.71	3.28	4.70	4.28	2.12	11.10	10.00	8.98	8.00	8.52	10.00	28 99	31 00
3.00	......	3.51	6.51	6.56	1.34	6.23	2.72	10.29	6.00	7.57	7.00	4.77	2.00	53 50	33 50
6.62	......	1.52	8.14	8.20	1.70	4.32	1.32	7.34	....	6.03	4.00	5.07	5.00	35 73	37 00
......	......	1.70	1.70	1.64	5.68	4.23	2.86	12.77	....	9.89	8.00	1.23	1.00	17 70	23 00
......	......	1.78	1.78	1.64	4.10	2.22	1.68	8.00	....	6.32	5.00	9.90	10.00	21 28	27 00
0.96	......	2.23	3.19	2.87	3.62	4.04	2.39	10.05	10.00	7.66	7.00	12.48	8.00	29 47	33 00
......	......	1.82	1.82	1.64	5.30	4.52	3.17	13.99	....	9.82	7.00	2.56	2.00	19 28	25 00
0.59	......	1.46	2.05	2.46	3.78	6.24	4.24	14.26	....	10.02	8.00	6.68	6.00	23 89	30 00
0.56	......	1.95	2.51	2.46	3.40	6.36	3.20	12.96	....	9.76	7.00	10.53	10.00	28 11	33 75
1.49	......	1.67	3.16	2.46	5.76	2.81	1.50	10.07	10.00	8.57	8.00	6.02	6.00	24 27	30 00
......	......	1.19	1.19	0.82	2.96	5.06	1.90	9.92	10.00	8.02	8.00	2.48	2.00	14 79	20 00
0.80	......	2.51	3.31	3.28	5.92	3.71	2.50	10.13	7.00	7.63	6.00	10.27	10.00	28 04	36 00
2.58	......	2.30	4.88	4.92	3.88	3.04	1.83	8.75	6.00	6.92	5.00	6.31	6.00	28 34	35 00
0.92	......	2.76	3.68	3.28	4.50	2.84	2.57	9.91	10.00	7.34	7.00	7.62	7.00	26 72	36 00
1.20	......	2.08	3.28	3.28	5.64	2.51	2.01	10.16	8.00	8.15	7.00	6.86	7.00	25 24	33 00
0.74	......	2.13	2.87	2.46	4.00	4.77	4.08	12.85	10.00	8.77	9.00	4.66	4.00	23 61	30 00
0.41	......	1.31	1.72	1.64	4.60	3.75	3.21	11.56	11.00	8.35	9.00	2.04	2.00	16 91	25 00
0.22	......	0.56	0.78	0.82	4.34	2.60	1.69	8.63	8.00	6.94	6.00	2.12	2.00	11 93	22 00
0.52	......	1.17	1.69	1.64	3.42	5.04	3.00	11.46	8.00	6.46	6.00	7.74	8.00	21 64	27 00
1.31	......	0.52	1.83	1.64	0.00	7.32	3.70	11.02	8.00	7.32	6.00	*1.88	2.00	16 33	28 00
0.73	......	1.91	2.64	2.46	6.13	3.58	2.89	12.60	11.00	9.71	9.00	2.21	2.00	21 24	30 00
0.22	......	0.81	1.03	0.82	2.76	4.70	2.97	10.43	11.00	7.46	9.00	2.23	2.00	13 88	21 00
......	......	1.95	1.95	1.64	2.72	4.65	5.55	12.92	12.00	7.37	6.00	2.14	2.00	17 33	24 00
0.29	......	0.74	1.03	0.82	0.78	6.10	3.95	10.83	10.00	6.88	8.00	2.91	3.00	14 24	23 00
3.38	......	......	3.38	3.28	7.90	2.13	2.65	12.68	8.00	10.03	6.00	4.90	5.00	35 40	50 00
......	0.27	2.13	2.40	2.46	2.08	3.18	3.81	9.07	8.00	5.26	....	4.08	4.00	18 17	23 00
0.55	......	1.29	1.84	1.64	3.96	4.65	4.61	13.22	10.00	8.61	8.00	2.08	2.00	18 13	35 00
0.41	......	1.36	1.77	1.64	3.50	4.75	5.27	13.52	10.00	8.25	8.00	2.09	2.00	17 86	26 00
0.82	......	1.76	2.58	0.82	1.98	6.63	4.60	13.21	8.00	8.61	6.00	4.18	6.00	22 27	35 00

* Potash largely, if not entirely, in form of sulphate.

Complete Fertilizers

Furnishing Nitrogen, Phosphoric Acid and Potash.

MANUFACTURER AND BRAND.	WHERE SAMPLED.	Station Number.
Bradley & Green Fertilizer Co., Philadelphia, Pa.		
Seven Per Cent. Ammonia Guano	Matawan	2301
Extra High-Grade Potato Guano	Freehold	2354
Wm. M. Brown, Cedarville, N. J.		
Special Potato Manure	Cedarville	2135
C. C. Clark & Son, Mt. Ephraim, N. J.		
Truckers' Joy	Mt. Ephraim	2049
E. Frank Coe Co., New York City.		
Famous Red Brand, Excelsior Guano	Freehold	2324
Alkaline Bone Phosphate	Skillman	2455
Peach Tree, Fruit and Grape Vine Fertilizer	Freehold	2325
Ammoniated Dissolved Bone Phosphate	Hightstown	2378
Extra Special Potato Fertilizer	Jamesburg	2356
Ground Bone and Potash	Hightstown	2380
XXV Ammoniated Bone Phosphate	Bound Brook	2605
Excelsior Guano	Elizabeth	2652
Famous American Lawn Fertilizer	Closter	2672
J. S. Collins & Son, Moorestown, N. J.		
Fish Guano	Moorestown	2026
Truck Guano	"	2027
High-Grade Fertilizer for Potatoes and General Use	"	2028
Cabbage and Tomato Fertilizer	"	2029
Collins & Pancoast, Merchantville, N. J.		
High-Grade Fertilizer for Potatoes and General Use	Merchantville	2068
Ten Per Cent. Guano	"	2064
Fish Guano	"	2065
Cabbage and Tomato Fertilizer	"	2066
Truck Guano	"	2067
A. A. Cortelyou, Neshanic Station, N. J.		
Special Fertilizer for Corn and Potatoes	Neshanic Station	2583
Wheat and Rye Special	" "	2506
Special Ammoniated Wheat and Rye	" "	2584
Special for Corn, Wheat and Rye	" "	2585
I. S. Curtis, Frenchtown, N. J.		
High Grade Bone Phosphate	Frenchtown	2485
Davis, Colson & Co., Woodstown, N. J.		
Our Bone Phosphate	Woodstown	2116
Potato and Tomato Phosphate	"	2117

Complete Fertilizers

Furnishing Nitrogen, Phosphoric Acid and Potash.

Nitrogen. From Nitrates.	Nitrogen. From Ammonia Salts.	Nitrogen. From Organic Matter.	Nitrogen. Total Found.	Nitrogen. Total Guaranteed.	Phosphoric Acid. Soluble in Water.	Phosphoric Acid. Soluble in Ammonium Citrate.	Phosphoric Acid. Insoluble.	Phosphoric Acid. Total Found.	Phosphoric Acid. Total Guaranteed.	Phosphoric Acid. Available. Found.	Phosphoric Acid. Available. Guaranteed.	Potash. Found.	Potash. Guaranteed.	Value of 2,000 lbs. at Station's Prices.	Selling Price of 2,000 lbs. at Consumers' Depot.
0.86	0.55	4.62	6.03	5.74	6.00	1.42	1.06	8.48	9.00	7.42	7.00	4.49	5.00	$31 31	$37 00
0.51	0.54	2.28	3.33	3.28	4.56	2.83	1.70	9.09	8.00	7.39	6.00	9.89	10.00	27 31	29 00
0.95	......	1.92	2.87	2.46	5.52	2.15	2.06	9.73	....	7.67	7.00	10.80	10.00	28 61	28 00
1.48	......	2.64	4.12	4.10	8.50	2.50	1.57	7.57	....	6.00	8.00	5.47	6.00	25 28	31 00
......	1.55	1.82	3.37	3.28	7.78	1.49	2.25	11.52	10.50	9.27	9.00	*6.17	6.00	27 47	34 00
......	......	1.36	1.36	1.23	8.30	1.53	2.78	12.56	10.00	9.83	8.50	*3.07	2.50	18 46	24 00
......	......	1.39	1.33	0.82	6.78	1.53	2.94	11.25	....	8.31	9.00	*5.19	5.00	19 07	28 00
......	......	1.53	1.53	1.23	6.14	2.01	3.84	11.99	10.00	8.15	8.00	*2.58	2.25	17 32	25 00
......	0.50	1.29	1.79	1.64	7.18	1.81	2.71	11.20	9.50	8.49	8.00	*9.32	10.00	24 78	28 00
......	......	1.68	1.63	1.64	0.00	5.85	11.82	17.67	14.00	5.85	....	2.16	2.00	17 73	28 00
......	......	1.30	1.30	0.82	8.26	1.48	3.45	13.14	10.00	9.69	8.50	2.29	1.50	17 31	23 50
......	0.88	2.17	3.05	3.28	8.66	1.21	2.60	11.87	10.00	9.27	9.00	*5.32	3.40	25 89	40 00
0.65	......	2.31	2.96	3.28	5.86	2.14	2.68	10.68	7.00	8.00	8.00	*4.43	4.00	23 07	38 00
......	0.56	1.80	2.36	2.46	6.10	2.01	1.21	9.32	....	8.11	8.00	3.65	4.00	19 48	26 00
......	0.22	1.46	1.68	1.64	5.16	2.96	1.32	9.44	....	8.12	8.00	2.00	2.00	16 90	23 00
0.81	......	1.67	2.48	2.46	4.32	4.09	1.53	9.94	....	8.41	8.00	*10.68	10.00	26 61	28 00
0.99	......	2.06	3.05	3.28	7.12	1.10	0.72	8.94	....	8.22	7.00	4.59	5.00	22 52	27 00
1.32	......	1.36	2.68	2.46	4.60	3.73	1.42	9.75	....	8.33	8.00	*10.52	10.00	26 88	28 00
0.86	3.08	3.94	7.88	8.20	2.76	2.16	0.87	5.79	....	4.92	4.00	4.48	4.00	34 82	45 00
......	0.49	1.87	2.36	2.46	6.52	1.88	1.25	9.65	....	8.40	8.00	3.87	4.00	19 99	26 00
1.10	......	2.31	3.41	3.28	6.76	1.12	0.68	8.56	....	7.88	7.00	4.97	5.00	23 30	27 00
......	0.23	1.56	1.79	1.64	5.26	2.70	1.47	9.43	....	7.96	8.00	1.98	2.00	16 15	23 00
......	0.62	2.12	2.74	3.28	1.52	5.07	3.48	10.07	12.00	6.59	....	4.40	8.00	20 77	30 00
......	......	1.77	1.77	1.64	7.10	0.91	0.84	8.85	....	8.01	8.00	2.15	2.00	16 02	21 00
......	......	1.79	1.79	1.64	4.86	3.22	2.83	10.91	....	8.08	8.00	2.51	2.00	17 25	20 00
......	0.22	0.54	0.76	1.64	0.00	8.25	2.70	10.95	....	8.25	8.00	2.81	2.00	14 25	22 00
0.51	......	1.21	1.72	1.64	3.28	3.29	3.04	9.61	....	6.57	8.00	3.30	3.00	16 19	25 00
0.25	0.51	2.58	3.34	2.87	6.50	2.08	0.82	9.40	9.00	8.58	8.00	*7.79	6.00	26 66	28 00
0.52	......	2.00	2.52	2.46	4.76	3.19	1.15	9.10	9.00	7.95	8.00	*7.15	5.00	22 97	24 00

* Potash largely, if not entirely, in form of sulphate.

Complete Fertilizers

Furnishing Nitrogen, Phosphoric Acid and Potash.

MANUFACTURER AND BRAND.	WHERE SAMPLED.	Station Number.
. F. Demaris & Son, Cedarville, N. J.		
Special Superphosphate	Bridgeton	2137
Fish Guano	"	2138
Complete Bone Fertilizer	"	2139
Truckers' Potato Manure	"	2140
. H. Denise, Freehold, N. J.		
High-Grade Fertilizer	Howell Station	2329
Complete Potato Manure	Freehold	2330
Excelsior Potato Manure	Cranbury	2331
. W. Doughten, Moorestown, N. J.		
Sure Shot Superphosphate	Moorestown	2030
Special Potato Manure	"	2031
Dried and Ground Fish Guano	"	2032
. G. Downward & Co., Coatesville, Pa.		
Royal Bone Phosphate	Ringoes	2507
Special Bone Fertilizer	"	2508
Frank Emmons, Newton, N. J.		
Special Potato Manure	Andover	2725
. C. Fifield & Sons Co., Bakersville, N. J.		
Special Potato and Cabbage Manure	Woodbury	2094
Special Sweet Potato Manure	"	2095
Fithian & Pennell, Bridgeton, N. J.		
Complete Phosphate	Bridgeton	2141
. O. Garrison, Bridgeton, N. J.		
Bay Side Fertilizer	Bridgeton	2142
Murphy Brands for Potatoes and Tomatoes	"	2143
Truckers' Pride	Erma	2231
Our Pride Fish Guano	"	2230
Gold Dust	Bridgeton	2146
Farmers' Pride	"	2147
Pride of Cumberland	"	2148
. C. Griscom, Woodbury, N. J.		
King Crab Compound	Woodbury	2096
Wyckoff Hendrickson, Allentown, N. J.		
Wheat and Rye Manure	Allentown	2626
High-Grade Potato Manure	Hamilton Square	2409
Corn and Truck Manure	Allentown	2623
Special Potato Manure	Robbinsville	2624

Complete Fertilizers

Furnishing Nitrogen, Phosphoric Acid and Potash.

Nitrogen.					Phosphoric Acid.							Potash.			
From Nitrates.	From Ammonia Salts.	From Organic Matter.	Total Found.	Total Guaranteed.	Soluble in Water.	Soluble in Ammonium Citrate.	Insoluble.	Total Found.	Total Guaranteed.	Available. Found.	Available. Guaranteed.	Found.	Guaranteed.	Value of 2,000 lbs. at Station's Prices.	Selling Price of 2,000 lbs. at Consumers' Depot.
......	......	0.82	0.82	0.82	6.96	2.40	1.02	10.38	10.00	9.38	....	1.54	1.00	$13 79	$19 00
......	......	2.04	2.04	2.46	6.82	2.41	1.48	10.16	9.00	8.73	....	2.34	2.50	18 02	23 00
0.66	.....	1.09	1.75	1.64	6.20	4.41	4.39	15.00	15.00	10.61	....	1.79	2.50	19 47	25 00
1.21	......	1.35	2.56	3.28	6.94	2.62	1.46	11.02	....	9.56	9.00	4.60	7.50	22 14	28 00
1.78	......	2.64	4.42	4.10	3.96	4.19	1.59	9.74	8.00	8.15	....	8.01	8.00	29 65	29 00
1.70	......	2.05	3.75	3.49	5.30	3.25	1.50	10.05	9.00	8.55	....	9.32	10.00	28 94	29 00
1.62	.....	2.72	4.34	4.31	3.88	4.31	2.07	10.26	9.25	8.19	....	8.74	8.75	30 29	32 00
......	......	2.36	2.36	2.46	9.04	1.85	2.33	13.22	11.00	10.89	10 00	3.90	3.00	22 93	27 00
......	1.74	1.04	2.78	2.46	8.70	1.36	1.54	11.60	....	10.06	10 00	7.23	7.00	26 00	29 00
......	......	3.65	3.65	3.69	1.74	1.74	3.53	7.01	5.85	3.48	....	3.91	3.00	20 26	28 00
......	......	0.87	0.87	0.82	3.32	4.34	2.04	9.70	9.00	7.66	8.00	2.67	2.00	13 62	23 00
......	......	1.11	1.11	1.23	2.80	4.45	2.01	9.26	10.00	7.25	7.00	2.75	2.50	14 07	28 00
1.15	.....	2.18	3.33	3.28	5.02	3.16	1.92	10.10	....	8.18	7.00	9.49	9.00	27 66	33 00
.....	......	2.52	2.52	2.46	3.62	4.14	1.60	9.36	....	7.76	7.00	7.74	7.00	23 30	35 00
.....	.. ..	2.25	2.25	2.05	2.30	4.74	1.47	8.51	... .	7.04	5.00	9.82	10.00	23 41	35 00
0.37	......	1.33	1.70	1.64	4.46	4.13	4.49	13.08	10.00	8.59	8.00	2.13	2.00	17 70	22 50
0.54	......	1.16	1.70	2.05	5.82	3.75	1.18	10.20	8.50	9.07	7.50	2.60	2.50	17 18	22 50
......	1.07	1.45	2.52	2.46	5.44	3.00	1.23	9.67	.. ..	8.44	8.00	9.43	10.00	25 27	30 00
1.65	......	1.31	2.96	3.28	4.94	3.18	1.05	9.17	....	8.12	8.00	5.08	7.00	22 15	28 00
0.81	......	1.55	2.36	4.10	3.64	4.49	1.59	9.72	... .	8.13	8.00	5.75	8.00	21 21	32 00
......	......	0.92	0.92	0.82	5.24	3.78	1.34	10.36	....	9.02	9.00	2.03	2.00	14 33	17 00
......	......	1.38	1.38	1.64	5.24	2.66	1.53	9.43	....	7.90	8.00	3.11	3.00	17 38	25 00
......	......	1.85	1.85	1.64	4.74	3.58	1.12	9.44	....	8.32	8.00	1.90	2.00	16 60	25 00
0.65	0.99	2.17	3.81	4.10	5.28	3.56	1.18	10.02	10.00	8.84	8.00	5.61	5.00	26 46	31 00
......	......	2.25	2.25	0.82	7.34	3.61	3.14	14.09	12.00	10.95	10.00	3.14	2.00	22 31	29 00
1.12	......	2.84	3.97	3.28	4.78	3.22	1.59	9.59	....	8.00	9.00	9.88	10.00	29 80	32 00
......	.....	2.27	2.27	1.64	7.16	3.65	2.38	13.19	11.00	10.81	9.00	4.32	4.00	22 82	27 00
1.01	......	2.34	3.35	2.46	6.12	2.50	1.09	9.71	10.00	8.62	8.00	9.86	10.00	28 18	32 00

Complete Fertilizers

Furnishing Nitrogen, Phosphoric Acid and Potash.

MANUFACTURER AND BRAND.	WHERE SAMPLED.	Station Number.
S. M. Hess & Bro., Philadelphia, Pa.		
Potato and Truck Manure	Ringoes	2509
Fish and Potash	Toms River	2281
Special Potato Manure	Cranbury	2359
Special Cabbage Manure	Ringoes	2510
Wheat and Grass Manure	German Valley	2712
G. C. Higgins & Son, Three Bridges, N. J.		
Golden Rod	Three Bridges	2516
Ira Hill, Copper Hill, N. J.		
Potato Fertilizer	Copper Hill	2513
Pure Bone Phosphate	" "	2514
Hill & Co., Flemington, N. J.		
Ten Per Cent. Potato Fertilizer	Flemington	2486
No. 2	"	2487
Standard Fertilizer	"	2512
Hires & Co., Quinton, N. J.		
Special Potato and Tomato Phosphate	Quinton	2282
Standard Bone Superphosphate	"	2283
W. B. Hitchner, Woodstown, N. J.		
High-Grade Potato Manure	Woodstown	2118
The Hobbard Fertilizer Co., Baltimore, Md.		
Standard Bone Superphosphate	Gloucester	2097
Royal Ensign for Early Market Vegetables	"	2098
Farmers' IXL Superphosphate	"	2099
Truckers' Seven Per Cent. Royal Seal Compound	"	2100
International Seed Co., Rochester, N. Y.		
Potato and Truck Manure	Cranbury	2360
A1 Special Manure	"	2361
Grain and Grass Fertilizer	Afton	2694
Hervey Kuhl, Flemington, N. J.		
Complete Fertilizer	Flemington	2634
Bone and Potash	"	2635
Lackawanna Fertilizer and Chemical Co., Moosic, Pa.		
Kali Chief	Erma	2176
Moosic Phosphate	Stillwater	2726
Bone Superphosphate	Baptistown	2491
Admiral Dewey	Pattenburg	2596
Special Manure	Blairstown	2718
Samuel Lederer & Sons, New Brunswick, N. J.		
Potato Fertilizer	South Bound Brook	2568

Complete Fertilizers

Furnishing Nitrogen, Phosphoric Acid and Potash.

Nitrogen.					Phosphoric Acid.							Potash.			
										Available.					
From Nitrates.	From Ammonia Salts.	From Organic Matter.	Total Found.	Total Guaranteed.	Soluble in Water.	Soluble in Ammonium Citrate.	Insoluble.	Total Found.	Total Guaranteed.	Found.	Guaranteed.	Found.	Guaranteed.	Value of 2,000 lbs. at Station's Prices.	Selling Price of 2,000 lbs. at Consumers' Depot.
......	0.96	1.25	2.21	2.46	4.18	4.36	1.86	10.40	....	8.54	8.00	5.09	6.00	$20 90	$20 00
......	......	2.28	2.28	2.05	5.42	2.86	2.31	10.61	....	8.30	8.00	3.07	3.00	19 78	30 00
0.50	0.73	1.74	2.97	3.28	7.02	1.92	1.67	10.61	....	8.94	8.00	6.79	7.00	25 03	30 00
.....	1.05	1.66	2.71	3.28	3.48	3.14	2.09	8.71	....	6.62	6.00	4.05	4.00	19 85	30 00
.....	......	1.03	1.03	0.82	5.36	2.85	2.79	10.50	9.00	7.71	8.00	2.57	2.00	14 42	22 00
......	......	1.16	1.16	1.23	6.42	1.88	1.92	10.22	....	8.30	8.00	4.18	4.00	16 45	21 00
......	......	2.51	2.51	2.46	1.80	6.76	1.54	10.10	....	8.56	10.50	9.04	9.00	25 14	29 00
......	....	2.17	2.17	2.05	2.02	6.61	1.82	10.45	....	8.63	10.50	3.55	2.50	19 64	24 00
......	....	1.80	1.80	1.64	4.24	3.48	1.50	9.22	9.00	7.72	8.00	10.75	10.00	23 40	27 00
......	....	1.08	1.08	0.82	3.76	3.85	2.68	10.29	9.00	7.61	8.00	2.25	2.00	14 15	20 00
......	......	2.22	2.22	2.05	3.80	3.22	2.64	9.66	8.00	7.02	7.00	2.83	2.50	17 82	23 00
0.87	0.21	1.35	2.43	2.46	6.32	1.59	2.65	10.56	10.00	7.91	8.00	4.71	5.00	20 88	24 00
0.41	0.22	1.17	1.80	1.64	5.56	2.31	2.56	10.43	9.50	7.87	8.00	3.29	3.00	17 50	21 00
......	......	2.20	2.20	2.46	5.80	1.82	1.87	9.49	....	7.62	7.00	8.38	8.00	22 75	23 00
0.86	......	1.00	1.86	1.64	5.62	2.49	2.38	10.49	....	8.11	8.00	2.91	3.00	17 41	25 00
0.94	......	1.17	2.11	2.46	6.36	2.58	2.73	11.67	....	8.94	8.00	4.52	4.00	20 65	28 00
0.92	......	1.13	2.05	1.64	4.46	3.16	2.90	10.52	....	7.62	8.00	2.44	2.00	17 34	23 00
1.17	1.99	2.08	5.24	5.74	5.40	1.57	0.92	7.89	....	6.97	6.00	5.23	5.00	28 73	35 00
......	......	1.50	1.50	1.23	4.82	3.75	2.34	10.91	9.00	8.57	8.00	7.05	7.00	20 45	27 00
0.55	0.92	0.76	2.23	2.46	2.20	4.51	1.76	8.47	7.00	6.71	6.00	10.39	10.00	23 44	33 00
......	......	1.79	1.79	1.64	7.44	2.90	2.54	12.88	11.00	10.34	10.00	2.36	2.00	19 28	25 00
0.56	......	2.15	2.71	2.46	6.06	4.36	3.64	14.06	....	10.42	12.00	1.80	2.00	22 29	28 00
......	......	0.95	0.95	0.82	6.40	3.97	2.60	12.97	10.00	10.37	8.00	1.13	1.00	15 51	20 00
......	......	1.28	1.28	0.82	4.04	1.83	1.82	7.74	8.00	5.92	7.00	7.91	8.00	17 59	22 00
......	......	1.42	1.42	1.23	6.50	2.66	1.10	10.26	9.00	9.16	7.00	2.83	1.50	16 70	25 00
......	......	1.36	1.36	1.64	8.32	2.54	1.29	12.15	12.00	10.86	10.00	2.55	2.00	18 04	24 00
......	......	1.54	1.54	0.82	3.56	3.45	3.20	10.21	7.00	7.01	6.00	1.21	1.00	13 74	20 00
......	......	2.35	2.35	2.46	6.92	2.91	1.62	11.45	12.00	9.83	10.00	5.59	6.50	22 95	32 00
0.86	1.02	2.08	3.92	3.28	0.20	7.40	4.56	12.16	12.00	7.60	....	1.71	8.00	23 65	30 00

Complete Fertilizers

Furnishing Nitrogen, Phosphoric Acid and Potash.

MANUFACTURER AND BRAND.	WHERE SAMPLED.	Station Number.
Lister's Agricultural Chemical Works, Newark, N. J.		
Special Ten Per Cent. Potato	Marlboro	2863
Standard Pure Bone Superphosphate	Red Bank	2316
Potato Manure	Verona	2653
Mount Rose Corn Fertilizer	Pennington	2431
Ammoniated Dissolved Bone Phosphate	Skillman	2460
U S. Superphosphate	Martinville	2586
"G" Brand	Lebanon	2558
Success Fertilizer	Pittstown	2538
Potato and Corn Fertilizer, No. 2	Martinville	2585
Special Corn and Potato Fertilizer	Middlebush	2607
Special Crop Producer Fertilizer	"	2608
Harvest Queen Phosphate	German Valley	2713
3-6-10 for Potatoes	Madison	2695
3-6-10 for Potatoes	Boonton	2751
The Mapes Formula & Peruvian Guano Co., N.Y. City.		
Potato Manure	Camden	2068
Cauliflower and Cabbage Manure	Newark	2656
Corn Manure	Matawan	2384
Fruit and Vine Manure	Hammonton	2179
Top Dresser—Half Strength	"	2180
Top Dresser—Full Strength	Matawan	2383
Complete Manure for Light Soils	"	2387
Complete Manure for Heavy Soils	"	2385
Complete Manure for Average Soils	"	2386
Complete Manure, "A" Brand	River Vale	2675
General Crop Brand	Pittstown	2541
Complete Manure, 10 per cent. Potash	Stockton	2492
Grain Brand	"	2493
Ammoniated Dissolved Bone with Potash	Pittstown	2540
Cereal Brand	Clinton	2564
Lawn Top Dressing	Newton	2729
Complete Manure for General Use	Montclair	2658
Grass and Grain Spring Top Dressing	Morristown	2696
John E. Minch, Bridgeton, N. J.		
Sweet Potato Manure	Bridgeton	2263
Complete Phosphate	"	2264
Mitchell Fertilizer Co., Tremley, N. J.		
Special Vegetable Fertilizer	Matawan	2335

Complete Fertilizers

Furnishing Nitrogen, Phosphoric Acid and Potash.

Nitrogen.					Phosphoric Acid.							Potash.			
										Available.					
From Nitrates.	From Ammonia Salts.	From Organic Matter.	Total Found.	Total Guaranteed.	Soluble in Water.	Soluble in Ammonium Citrate.	Insoluble.	Total Found.	Total Guaranteed.	Found.	Guaranteed.	Found.	Guaranteed.	Value of 2,000 lbs. at Station's Prices.	Selling Price of 2,000 lbs. at Consumers' Depot.
......	......	1.77	1.77	1.64	7.48	1.20	1.18	9.86	....	8.68	8.00	*9.35	10.00	$24 34	$28 00
......	0.41	1.57	1.98	2.46	9.10	1.52	2.00	12.62	11.00	10.62	9.00	2.49	2.00	20 06	28 00
......	0.92	1.99	2.91	3.28	7.82	1.77	1.69	10.79	9.00	9.09	8.00	7.21	7.00	25 51	34 00
......	......	2.12	2.12	1.64	6.88	1.62	2.11	10.61	10.00	8.50	8.00	1.87	1.00	17 93	23 00
......	......	1.67	1.67	2.05	7.22	2.38	2.10	11.70	9.00	9.60	8.00	2.84	1.50	18 11	25 00
......	0.28	1.06	1.34	1.03	7.80	0.97	1.86	10.63	10.00	6.77	8.00	*2 28	2.00	16 03	24 00
......	......	1.38	1.38	0.82	6.94	1.56	1.67	10.17	10.00	8.50	8.00	2.68	4.00	16 00	22 00
......	0.24	1.09	1.33	1.23	8.80	1.25	1.89	11.44	11.00	9.55	9.00	*2.31	2.00	16 82	22 00
......	0.76	1.10	1.86	1.64	8.58	1.74	2.56	12.88	....	10.32	10.00	*3.96	4.00	21 09	27 00
......	......	1.77	1.77	1.64	7.56	1.08	1.58	10.12	9.00	8.69	8.00	2.97	3.00	17 57	24 00
......	......	1.06	1.06	0.82	6.60	0.98	1.28	8.76	8.00	7.53	7.00	*1.41	1.00	12 93	20 00
......	......	1.37	1.37	1.23	7.08	2.80	3.88	13.26	11.00	9.38	9.00	*1.51	2.00	17 26	20 00
......	0.20	2.56	2.76	2.46	7.56	1.30	2.12	10.98	....	8.86	6.00	5.40	10.00	23 41	33 00
......	0 86	1.47	2.33	2.46	5.88	1.55	0.87	8.30	....	7.43	8.00	*8.93	10.00	24 23	30 00
1.71	......	2.30	4.01	3.69	2.96	5.14	2.18	10.23	8.00	8.10	8.00	*7.03	6.00	26 50	36 50
2.66	0.21	1.36	4.23	4.10	2.46	6.21	1.45	9.12	6.00	7.67	6.00	7.29	6.00	27 61	36 00
0.74	......	2.00	2.74	2.46	2.00	6.88	2.60	10.93	10.00	8.33	8.00	6.06	6.00	23 34	35 00
0.95	0.38	0.98	2.24	1.64	2.42	3.96	2.05	8.43	7.00	6.38	5.00	*10.95	10.00	24 91	41 00
4.57	......	0.35	4.92	4.92	0.62	2.30	1.30	4.22	4.00	2.92	....	*2.16	2.00	20 47	33 00
7.85	0.20	0.88	8.93	9.84	1.46	4.81	3.10	9.37	8.00	6.27	....	*4.50	4.00	39 12	60 00
3.28	......	1.91	5.19	4.92	2.06	4.47	2.41	8.94	8.00	6.53	6.00	*7.48	6.00	30 90	40 00
2.57	......	2.37	4.94	4.92	2.54	5.25	2.71	10.50	10.00	7.79	8.00	*3.68	3.00	28 08	39 00
2.25	......	2.28	4.53	4.10	2.62	4.87	1.80	8.79	8.00	6.99	7.00	*5.77	5.00	27 75	36 00
1.67	......	1.23	2.90	2.46	3.18	7.87	2.96	13.51	12.00	10.55	10.00	3.38	2.50	23 67	35 00
......	......	1.81	1.81	1.64	2.72	5.31	2.46	10.49	10.00	8.03	8.00	2.50	2.00	17 11	24 00
0.41	......	1.94	2.35	2.05	1.04	8.90	1.44	6.38	5.00	4.94	3.00	10.40	10.00	21 99	30 00
......	......	1.12	1.12	0.82	2.54	5.12	1.78	9.44	....	7.66	8.00	4.27	4.00	15 72	23 00
......	......	1.45	1.45	1.23	5.50	6.06	1.87	13.42	12.00	11.55	10.00	2.08	1.50	18 85	28 00
0.57	......	1.37	1.94	1.64	2.20	5.14	1.70	9.04	8.00	7.34	6.00	3.17	3.00	16 94	29 00
1.96	......	0.54	2.50	2.46	0.44	8.28	1.28	5.05	3.50	3.72	....	3.54	2.50	14 92	30 00
1.05	0.21	2 26	3.52	3.28	1.74	6.87	2.48	10.54	10.00	8.11	8.00	4.83	4.00	24 49	35 00
2.74	......	2.36	5.10	4.92	1.92	5.48	1.88	9.23	6.00	7.40	5.00	7.30	7.00	30 35	41 00
......	......	1.48	1.48	1.64	4.90	1.87	2.59	9.36	....	6.77	9.00	12.32	10.00	23 16	30 00
1.30	......	1.14	2.44	2.05	7.68	1.65	2.62	11.95	....	6.33	9.00	4.38	4.00	21 76	24 00
0.82	......	2.38	3.20	3.49	6.08	4.65	1.76	12.51	10.00	10.73	8.00	6.83	6.00	27 61	38 00

* Potash largely, if not entirely, in form of sulphate.

Complete Fertilizers

Furnishing Nitrogen, Phosphoric Acid and Potash.

MANUFACTURER AND BRAND.	WHERE SAMPLED.	Station Number.
Mixner and Mickel, Bridgeton, N. J.		
Phosphate for Oats	Bridgeton	2257
High-Grade for Potatoes and Sweet Potatoes	"	2258
Top Dresser for Strawberries and Asparagus	"	2259
Special for Wheat, Oats and Peas	"	2260
Fish Mixture for Tomatoes and Sweet Potatoes	"	2261
Complete for Corn, Wheat, Potatoes and Tomatoes	"	2262
Monmouth Fertilizer Works, Shrewsbury, N. J.		
Special Potato Manure	Shrewsbury	2319
Albert Nelson and Co., Allentown, N. J.		
Corn and Truck Fertilizer	Cranbury	2364
Potato Fertilizer	"	2390
Special Potato Manure	Windsor	2413
Complete Potato and Truck	Allentown	2414
High-Grade Superphosphate	Hamilton Square	2415
"A" Brand, Special Potato	" "	2416
Complete Potato Manure	Windsor	2417
Willetts' Brand, Special Potato Manure	Cranbury	2389
New Jersey Agricultural Chem. Co., Newark, N. J.		
Russell's Special Potato Fertilizer	Pennington	2486
Russell's Ammoniated Dissolved Bone Phosphate	Rocky Hill	2464
Russell's Two Tons in One	Hopewell	2438
Russell's Ten Per Cent. Potato Fertilizer	Flemington	2518
Russell's Champion Manure	Hopewell	2440
Russell's Special Corn Manure	Rocky Hill	2463
Russell's Potato Manure	Somerville	2592
Newport Fertilizer Co., Philadelphia, Pa.		
No. 1 Bone Phosphate	Cold Spring	2282
Fish, Bone and Potash	Cranbury	2384
Gilt Edge Potato and Tobacco Manure	Stockton	2495
Gilt Edge Potato and Tobacco Manure	Bergenfields	2677
Truckers' Joy	Bridgeton	2268
Truckers' Joy	Matawan	2341
Evans Brand	Bennett's Mills	2285
Rectified Phosphate	Matawan	2340
Potato, Tobacco and Truck Guano	Pennington	2485
Grain and Grass Special	Columbus	2411
Farmers' Ammoniated Bone Phosphate	Hightstown	2387
Special Compound	Jobstown	2412
Clark's High Grade	Mt. Ephraim	2047

Complete Fertilizers

Furnishing Nitrogen, Phosphoric Acid and Potash.

Nitrogen. From Nitrates.	Nitrogen. From Ammonia Salts.	Nitrogen. From Organic Matter.	Nitrogen. Total Found.	Nitrogen. Total Guaranteed.	Phosphoric Acid. Soluble in Water.	Phosphoric Acid. Soluble in Ammonium Citrate.	Phosphoric Acid. Insoluble.	Phosphoric Acid. Total Found.	Phosphoric Acid. Total Guaranteed.	Phosphoric Acid. Available. Found.	Phosphoric Acid. Available. Guaranteed.	Potash. Found.	Potash. Guaranteed.	Value of 2,000 lbs. at Station's Prices.	Selling Price of 2,000 lbs. at Consumers' Depot.
0.89	......	0.93	1.32	0.82	4.00	3.50	2.88	10.38	....	7.50	8.00	2.45	3.00	$14 97	$18 00
0.87	......	1.45	2.32	2.46	4.20	2.43	2.15	8.78	....	6.63	6.00	*9.86	10.00	23 94	30 00
0.60	......	2.17	2.77	4.51	5.64	1.87	2.89	10.40	....	7.51	6.00	7.06	10.00	25 63	33 00
0.70	0.21	0.84	1.75	1.64	5.54	2.16	2.54	10.24	....	7.70	8.00	3.60	3.00	17 34	22 00
0.21	......	2.39	2.60	2.46	4.64	1.85	2.19	8.68	....	6.49	7.00	4.33	3.00	19 57	25 00
1.32	......	1.20	2.52	2.46	6.50	1.38	2.62	10.50	....	7.88	8.00	5.25	5.00	21 31	25 00
......	......	2.85	2.35	2.46	1.52	2.44	1.88	5.29	....	3.96	6.00	7.60	8.00	18 71	31 00
1.11	......	1.53	2.64	2.46	5.20	5.05	2.56	12.81	10.00	10.25	8.00	4.84	4.00	23 76	25 00
2.15	......	2.06	4.21	3.28	4.44	3.18	1.31	8.93	....	7.62	6.00	9.89	10.00	28 80	33 00
0.65	......	1.09	1.74	1.64	5.28	4.51	2.57	12.36	....	9.79	8.00	10.60	10.00	25 38	27 00
0.78	......	1.09	1.87	1.64	6.42	2.87	2.14	11.43	....	9.29	9.00	10.22	10.00	24 78	28 00
0.46	......	1.13	1.59	1.64	3.18	5.84	4.18	13.20	10.00	9.02	8.00	3.41	3.00	18 70	23 00
1.19	......	1.55	2.74	2.46	4.68	4.23	2.09	11.00	....	8.91	6.00	10.29	10.00	27 19	28 00
0.73	......	1.89	2.62	2.46	4.02	3.21	1.80	9.03	....	7.23	6.00	6.39	6.00	21 81	27 00
1.77	......	2.11	3.88	3.28	7.78	0.68	0.14	8.60	....	8.46	6.00	10.00	10.00	29 29	34 00
......	......	1.51	1.51	1.64	4.40	5.21	6.14	15.75	9.00	9.61	8.00	3.58	3.00	20 09	24 00
......	......	1.84	1.84	1.89	4.40	4.99	6.73	16.12	11.00	9.39	9.00	2.82	1.50	20 55	24 00
......	......	2.19	2.19	2.05	1.78	9.06	6.96	17.80	20.00	10.84	....	2.58	2.50	25 04	31 00
......	......	1.68	1.68	1.64	4.60	3.88	4.60	13.08	9.00	8.48	8.00	9.65	10.00	24 06	27 00
......	......	0.73	0.73	0.82	3.56	5.40	6.59	15.55	9.00	8.96	8.00	1.90	2.00	15 63	21 00
......	......	1.77	1.77	1.64	4.30	4.79	7.22	16.31	9.00	9.09	8.00	2.92	3.00	20 30	24 00
......	......	3.63	3.63	3.69	2.86	4.62	3.92	11.40	8.50	7.48	7.50	5.73	7.00	25 90	35 00
......	......	1.44	1.44	1.64	4.66	3.20	2.49	10.35	9.00	7.86	8.00	2.17	2.00	15 46	25 00
......	......	1.54	1.54	1.64	5.62	2.08	4.06	11.71	8.00	7.65	7.00	6.59	5.00	19 10	28 00
......	......	1.50	1.50	1.64	6.86	1.66	2.06	10.58	9.00	8.52	8.00	6.18	10.00	21 24	26 00
......	......	1.99	1.99	1.64	4.24	2.60	3.80	10.64	9.00	6.84	8.00	8.89	10.00	21 46	33 00
1.10	......	2.40	3.50	4.10	4.24	2.58	2.96	9.78	9.00	6.82	8.00	4.45	6.00	23 03	35 00
1.26	......	2.60	3.86	4.10	2.76	3.18	1.83	7.77	9.00	5.94	8.00	6.09	6.00	24 21	28 00
1.29	......	1.89	3.18	3.28	4.82	1.66	2.20	8.38	8.00	6.66	7.00	10.68	10.00	26 75	38 00
1.40	......	1.61	3.01	3.28	3.76	2.70	2.84	9.30	8.00	6.46	7.00	4.97	5.00	21 14	35 00
0.29	......	0.52	0.81	0.82	3.28	2.63	1.92	7.83	7.00	5.91	6.00	6.01	6.00	14 58	28 00
......	......	0.98	0.98	0.41	2.48	3.28	3.12	8.78	9.00	5.66	8.00	1.55	2.00	11 46	29 00
......	......	0.70	0.70	0.82	2.65	3.56	2.99	8.45	8.00	6.46	7.00	2.71	4.00	12 27	24 00
......	......	1.06	1.06	0.82	5.56	1.98	4.27	11.81	11.00	7.54	10.00	2.14	2.00	14 83	22 00
1.84	......	1.24	3.08	3.28	3.92	2.38	2.17	8.47	....	6.30	8.00	6.70	7.00	22 42	30 00
0.50	......	1.27	1.77	1.64	5.28	2.20	2.04	9.52	....	7.48	8.00	5.12	5.00	18 54	28 00

Complete Fertilizers

Furnishing Nitrogen, Phosphoric Acid and Potash.

MANUFACTURER AND BRAND.	WHERE SAMPLED.	Station Number.
James E. Otis, Tuckerton, N. J.		
Special for Potatoes	Jackson's Mills	2286
Menhaden Fish Guano	Mount Holly	2418
S. L. Pancoast, Mullica Hill, N. J.		
Early Potato Grower	Mullica Hill	2119
Early Truck Fertilizer	" "	2120
Peterson & Smith, Woodstown, N. J.		
Wheat and Oats Superphosphate	Woodstown	2121
High-Grade Potato Fertilizer	"	2122
Potato Superphosphate	"	2123
R. H. Pollock, Baltimore, Md.		
Ammoniated Bone Phosphate	Milford	2544
Special Wheat Grower	"	2545
Owl Brand Guano	"	2547
Quaker City Pondrette Co., Philadelphia, Pa.		
Quaker City Pondrette	Mount Holly	2072
John Repp, Glassboro, N. J.		
High-Grade Fertilizer	Glassboro	2102
Enos Richmond, Elmer, N. J.		
Special Potato Phosphate	Hainesburg	2720
Special Corn Manure	"	2721
Edward Rigg, Jr., Burlington, N. J.		
Potato Manure	Burlington	2087
Fish Guano	"	2088
M. F. Riley, Elmer, N. J.		
Potato Fertilizer	Elmer	2268
High-Grade Potato	"	2269
Ruckman Bros., New Brunswick, N. J.		
Corn Fertilizer	New Brunswick	2631
C. W. Saul, Rio Grande, N. J.		
Anti-Trust Potato and Tomato Guano	Rio Grande	2182
Sharpless & Bro., Camden, N. J.		
Ten Per Cent Truck Guano	Camden	2073
Extra High-Grade Potato Manure	"	2074
Seven Per Cent. Guano	"	2075
No. 1 for General Use	"	2076

Complete Fertilizers

Furnishing Nitrogen, Phosphoric Acid and Potash.

Nitrogen.					Phosphoric Acid.							Potash.			
										Available.					
From Nitrates.	From Ammonia Salts.	From Organic Matter.	Total Found.	Total Guaranteed.	Soluble in Water.	Soluble in Ammonium Citrate.	Insoluble.	Total Found.	Total Guaranteed.	Found.	Guaranteed.	Found.	Guaranteed.	Value of 2,000 lbs. at Station's Prices.	Selling Price of 2,000 lbs. at Consumers' Depot.
......	0.34	2.33	2.67	1.64	8.06	4.27	1.96	9.29	8.00	7.33	....	*4.81	10.00	$21 73	$29 00
......	0.43	2.89	3.32	3.28	8.40	4.62	1.97	9.89	7.00	7.92	....	*2.58	5.00	22 25	28 00
0.74	......	2.48	3.22	3.28	5.82	2.87	1.55	9.74	....	8.19	7.00	7.70	7.50	25 76	28 00
0.44	.....	2.42	2.86	2.67	6.24	2.74	1.86	10.84	....	8.98	8.00	5.04	5.00	23 31	25 00
......	......	0.96	0.96	0.82	5.10	3.96	2.12	11.18	....	9.06	8.00	1.96	2.00	14 75	17 00
1.08	......	2.02	3.10	3.28	3.98	3.72	1.78	9.48	....	7.70	8.00	8.29	8.00	25 37	28 00
0.51	......	1.57	2.08	1.64	3.00	4.26	1.84	9.10	....	7.26	6.00	10.03	10.00	23 23	27 00
......	0.33	1.44	1.77	1.64	4.40	3.69	*1.23	9.32	9.00	8.09	8.00	2.37	2.00	16 44	23 00
......	......	0.95	0.95	0.82	6.12	2.58	2.62	11.32	10.00	8.70	9.00	2.16	2.00	14 73	21 50
......	......	0.63	0.63	0.41	8.90	3.25	2.23	9.38	8.00	7.15	7.00	1.56	1.50	11 45	19 50
0.20	0.19	0.93	1.32	1.64	0.48	2.92	0.22	3.62	4.00	3.40	....	0.27	1.00	8 02	16 60
......	......	2.06	2.06	2.05	4.50	3.76	2.30	10.56	10.00	8.26	8.00	10.45	10.00	24 86	26 00
.....	0.55	1.34	1.89	1.64	6.72	1.64	1.97	10.33	9.00	8.36	8.00	9.90	10.00	23 61	27 50
......	......	0.90	0.90	0.82	7.10	2.39	2.26	11.69	....	9.43	9.00	3.71	3.00	16 45	19 50
......	0.22	1.40	1.62	1.64	6.84	2.18	1.04	9.51	....	8.47	8.00	9.28	10.00	22 13	27 00
......	0.52	1.86	2.38	2.46	4.58	2.77	1.07	8.42	....	7.35	7.00	6.22	5.00	20 08	26 00
0.43	......	1.40	1.83	1.64	4.06	3.83	1.47	9.36	....	7.89	8.00	7.67	7.00	20 83	25 00
1.02	......	1.71	2.73	2.46	4.28	3.66	1.40	9.34	....	7.94	7.00	9.14	8.00	24 97	25 00
......	1.14	2.74	3.88	5.00	2.24	5.22	4.14	11.60	8.00	7.46	6.00	3.47	3.00	24 87	25 00
0.68	......	1.80	2.48	2.46	5.84	3.31	1.60	8.75	....	7.15	7.00	8.11	7.00	22 66	27 00
2.38	......	5.13	7.51	8.20	1.26	3.30	1.80	6.36	....	4.56	4.00	4.87	4.00	35 52	45 00
1.27	......	1.90	3.17	3.28	4.08	1.91	2.72	8.71	....	5.99	7.00	9.84	10.00	25 52	32 00
2.47	......	2.67	5.14	5.74	3.32	1.89	1.90	7.11	....	5.21	5.00	10.00	9.00	30 69	38 00
1.28	......	1.36	2.60	1.64	5.20	1.85	3.47	10.52	....	7.05	3.00	2.45	2.00	18 69	24 00

* Potash largely, if not entirely, in form of sulphate.

Complete Fertilizers

Furnishing Nitrogen, Phosphoric Acid and Potash.

MANUFACTURER AND BRAND.	WHERE SAMPLED.	Station Number.
M. L. Shoemaker & Co., Philadelphia, Pa.		
Swift-Sure 10 Per Cent. Potato Special, No. 1	Hartford	2039
Swift-Sure Superphosphate for Potatoes	Woodstown	2124
Swift-Sure Guano for Fall Trade	"	2125
Swift-Sure Guano for Tomatoes, Truck and Corn	Egg Harbor City	2215
Swift-Sure Superphosphate for General Use	Hamilton Square	2419
Swift-Sure New Jersey Special for Oats	Pleasantville	2240
$23-Phosphate	Woodstown	2127
Good Enough Superphosphate	Rio Grande	2184
Muzzy Bros. Special	Paterson	2700
Lester Shurts, Neshanic Station, N. J.		
Standard Bone Phosphate	Neshanic Station	2554
L. W. Sickler, Glassboro, N. J.		
Special 10 Per Cent. Potato Fertilizer	Glassboro	2103
Guano for Tomatoes, Truck and Corn	"	2104
Jos. Smith & Co., Stockton, N. J.		
Oats Fertilizer	Stockton	2498
Special Potato Fertilizer	"	2499
Special Fertilizer	"	2500
Standard Fertilizer	"	2501
Prallsville Formula	"	2502
***Rufus* W. Smith, Elmer, N. J.**		
Banner Truck Manure	Elmer	2151
Complete Bone Fertilizer	"	2153
Ammoniated Consummate Fertilizer	"	2154
High-Grade Trucker Fertilizer	"	2155
Somerset Chemical Co., Bound Brook, N. J.		
5-8-7 Fertilizer	Bound Brook	2593
Cereal Bone Phosphate	" "	2609
Harvest Queen Phosphate	" "	2610
3-8-4 Fertilizer	" "	2688
Henry Taylor, Vineland, N. J.		
$25-Potato Manure	Vineland	2190
Farm and Garden	"	2191
Special Potato Fertilizer, No. 1	"	2192
Special Potato Manure, No. 2	"	2193

Complete Fertilizers

Furnishing Nitrogen, Phosphoric Acid and Potash.

Nitrogen.					Phosphoric Acid.							Potash.			
										Available.					
From Nitrates.	From Ammonia Salts	From Organic Matter.	Total Found.	Total Guaranteed.	Soluble in Water.	Soluble in Ammonium Citrate.	Insoluble.	Total Found.	Total Guaranteed.	Found.	Guaranteed.	Found.	Guaranteed.	Value of 2,000 lbs. at Station's Prices.	Selling Price of 2,000 lbs. at Consumers' Depot.
1.29	......	2.12	3.41	3.28	4.94	2.79	2.07	9.80	....	7.73	6.00	11.04	10.00	$28 81	$27 00
0.87	......	1.70	2.57	2.46	6.56	8.83	4.30	14.69	11.00	10.39	8.00	7.44	6.50	26 65	32 00
0.71	......	1.18	1.89	1.64	4.22	4.69	4.46	13.37	....	8.91	8.00	5.93	5.00	21 74	25 00
0.81	......	1.22	2.03	1.64	5.40	4.25	4.12	13.77	....	9.65	8.00	5.36	5.00	22 32	27 50
1.06	......	1.67	2.73	2.46	7.12	3.25	4.85	14.72	14.00	10.37	9.00	5.25	4.00	25 26	32 00
......	......	1.81	1.31	0.82	4.92	4.95	5.61	15.48	....	9.87	8.00	2.09	2.00	18 21	24 00
......	......	1.26	1.26	0.82	1.40	6.50	6.69	14.59	8.00	7.90	6.00	1.95	1.00	16 40	20 00
0.54	......	1.53	2.07	1.64	6.84	4.15	4.51	15.00	12.00	10.49	8.00	2.53	2.00	21 11	27 00
1.00	......	1.55	2.55	2.46	7.76	3.28	4.35	15.39	....	11.04	10.00	5.30	4.00	23 41	28 00
......	......	1.48	1.48	0.82	5.60	2.75	1.72	10.07	9.00	8.35	8.00	4.71	4.00	17 92	21 00
0.70	......	1.55	2.25	2.05	4.94	5.05	3.59	13.58	....	9.99	8.00	10.66	10.00	27 71	35 00
0.74	......	1.54	2.28	1.64	5.62	4.50	3.50	13.62	....	10.12	8.00	5.65	5.00	23 62	28 00
......	......	1.38	1.38	0.82	3.84	3.92	2.53	9.79	8.00	7.26	7.00	1.42	1.00	14 03	16 50
......	......	2.60	2.60	2.46	3.50	3.99	1.84	9.33	7.00	7.49	6.00	10.83	10.00	26 02	29 00
......	......	1.20	1.20	0.82	5.42	2.98	2.02	10.42	9.00	8.40	8.00	2.40	2.00	15 21	18 00
......	......	1.32	1.32	0.82	4.70	3.60	2.19	10.49	9.00	8.30	8.00	4.28	4.00	17 18	20 00
......	0.65	1.94	2.59	2.05	3.18	4.66	2.50	10.34	9.00	7.84	8.00	6.26	6.00	22 71	25 00
......	1.36	2.08	3.44	3.23	4.18	3.31	1.47	8.96	9.00	7.49	7.00	*7.56	8.00	28 79	27 00
......	0.85	2.01	2.36	2.05	5.76	2.58	1.15	9.49	10.00	8.34	8.00	4.28	3.00	20 23	20 00
......	......	1.19	1.19	0.82	6.84	2.81	1.00	9.65	10.00	8.65	9.00	2.56	3.00	15 16	17 00
......	......	2.69	2.69	2.46	5.22	2.23	1.66	9.11	9.00	7.45	7.00	*8.35	8.00	25 34	26 00
0.60	0.71	1.51	2.82	4.10	....	9.71	8.40	18.11	....	9.71	8.00	6.07	7.00	27 35	26 00
......	0.23	1.15	1.38	1.64	....	10.94	7.76	18.70	....	10.94	8.00	1.61	5.00	19 97	30 00
......	0.33	0.39	0.72	0.82	....	11.30	3.13	14.43	....	11.30	10.00	4.26	4.00	19 55	25 00
0.56	0.31	0.94	1.81	2.46	....	8.73	1.57	10.30	....	8.73	8.00	4.74	4.00	19 19	25 00
......	......	1.50	1.50	1.23	4.44	2.33	1.01	7.78	....	6.77	6.00	5.06	5.00	16 42	25 00
0.35	......	1.66	2.01	1.85	2.20	2.92	1.39	6.51	....	5.12	5.00	1.45	1.00	13 44	25 00
0.54	......	1.34	1.88	1.64	4.10	4.46	2.76	11.32	....	8.56	8.00	10.05	10.00	24 24	27 00
......	0.24	1.58	1.82	1.64	6.40	2.24	1.01	9.65	....	8.64	8.00	9.72	10.00	25 30	27 00

*Potash largely, if not entirely, in form of sulphate.

Complete Fertilizers

Furnishing Nitrogen, Phosphoric Acid and Potash.

MANUFACTURER AND BRAND.	WHERE SAMPLED.	Station Number.
Taylor Bros., Camden, N. J.		
High-Grade Potato Phosphate	Camden	2058
Animal Bone Phosphate	"	2079
The Taylor Provision Co., Trenton, N. J.		
*Special Potato Fertilizer	Cedarville	2157
High-Grade Corn and Truck Manure	Hammonton	2187
High-Grade Potato and Truck Fertilizer	Cranbury	2371
A. D. B. Special Fertilizer	Lambertville	2520
Ammoniated Dissolved Bone and Potash	"	2521
Bone, Tankage and Potash	Millstone	2611
I. P. Thomas & Son Co., Philadelphia, Pa.		
High-Grade Potato Manure	Moorestown	2018
Cabbage Manure	"	2041
Special Sweet Potato Manure	Davis	2224
Special Potato Manure	Moorestown	2043
Potato Fertilizer	Salem	2290
Vegetable Manure	"	2291
Special High-Grade Potato Manure	Davis	2225
Farmers' Choice Bone Phosphate	Robbinsville	2421
Potash and Improved	Flemington	2525
Wheat and Grass Compound	Titusville	2466
Improved Superphosphate	"	2468
Grain Manure	"	2469
Normal Bone Phosphate	"	2470
Special Fish Mixture	Beverly	2640
Trenton Bone Fertilizer Co., Trenton, N. J.		
Excelsior	Elmer	2273
High Grade Potato Fertilizer	Cranbury	2378
Special Potato Manure	Princeton Junction	2475
Corn Mixture	Plainsboro	2627
$32 Potato Manure	Robbinsville	2424
Superphosphate	"	2425
Potato Manure	Ringoes	2524
Bergen Special for Spring	Ewingville	2447
Grain Manure	Middlebush	2614
Stults' Special for Wheat and Grass	"	2615
XX Brand Fertilizer	"	2617

Complete Fertilizers

Furnishing Nitrogen, Phosphoric Acid and Potash

Nitrogen. From Nitrates.	Nitrogen. From Ammonia Salts.	Nitrogen. From Organic Matter.	Nitrogen. Total Found.	Nitrogen. Total Guaranteed.	Phosphoric Acid. Soluble in Water.	Phosphoric Acid. Soluble in Ammonium Citrate.	Phosphoric Acid. Insoluble.	Phosphoric Acid. Total Found.	Phosphoric Acid. Total Guaranteed.	Phosphoric Acid. Available. Found.	Phosphoric Acid. Available. Guaranteed.	Potash. Found.	Potash. Guaranteed.	Value of 2,000 lbs. at Station's Prices.	Selling Price of 2,000 lbs. at Consumers' Depot.
......	......	2.07	2.07	1.64	4.38	2.14	1.29	7.81	....	6.52	5.00	10.67	10.00	$22 94	$25 00
......	......	2.17	2.17	1.64	5.54	3.48	2.37	11.39	....	9.02	8.00	1.41	1.00	18 33	19 00
0.79	.....	1.13	1.92	2.05	4.88	3.63	3.43	11.44	....	8.01	8.00	11.06	10.00	24 88	29 00
0.93	......	1.59	2.52	2.46	5.32	4.78	2.92	13.02	....	10.10	10.00	6.97	5.00	25 24	28 50
1.63	......	1.36	2.99	2.87	8.58	3.92	4.77	12.27	12.00	7.50	8.00	9.70	10.00	27 04	31 00
1.18	......	1.15	2.33	1.23	2.96	4.16	3.84	9.56	8.00	6.22	....	6.95	5.00	20 81	24 50
......	......	1.43	1.43	1.23	4.44	3.14	3.88	11.46	8.00	7.58	....	4.37	2.50	17 74	24 25
0.42	......	0.75	1.17	0.82	7.28	3.56	5.50	10.34	7.00	10.84	....	3.49	2.50	19 75	20 00
0.64	......	1.75	2.39	2.46	4.02	3.70	*2.32	10.04	10.00	7.72	8.00	9.06	10.00	24 56	30 00
......	0.82	2.24	3.06	3.28	3.82	4.50	3.35	11.67	9.00	8.32	7.00	*5.03	5.00	24 79	28 00
......	......	2.15	2.15	1.43	6.84	2.67	3.44	12.95	9.00	9.51	7.00	12.25	10.00	28 40	30 00
......	......	1.83	1.83	1.64	3.92	3.64	2.03	9.59	8.00	7.56	7.00	11.01	10.00	23 76	23 00
0.51	......	1.32	1.83	1.64	4.42	4.36	2.17	10.95	10.50	8.78	9.00	6.36	6.00	23 95	28 00
......	.....	1.79	1.79	1.64	3.82	5.18	3.54	12.54	....	9.00	9.00	2.38	4.00	18 35	27 00
......	1.48	1.90	3.38	2.05	7.42	1.92	0.77	10.11	....	9.34	8.00	10.99	10.00	30 14	32 00
......	......	1.88	1.88	1.64	9.86	2.63	0.45	12.44	10.50	11.99	9.50	2.49	2.00	20 49	28 00
......	......	1.64	1.64	0.82	7.84	3.62	2.20	13.16	12.00	10.96	10.00	2.53	1.00	19 40	25 00
......	.....	0.9-	0.98	0.82	8.02	2.62	1.61	12 25	11.00	10.64	10.00	1.78	1.00	16 02	25 50
......	......	0.93	0.93	0.82	7.38	3.20	1.81	12.39	12.00	10.58	10.00	1.70	1.00	15 83	23 00
......	......	0.87	0.87	0.82	2.50	6.26	2.23	9.99	8.00	7.76	7.00	1.90	1.00	13 14	20 00
......	......	1.28	1.28	1.03	4.50	4.95	1.31	10.76	9.50	9.45	8.50	2.19	1.50	16 05	25 00
......	0.39	5.18	5.57	4.10	2.44	3.14	1.13	6.71	7.00	5.58	5.50	1.83	1.75	25 97	28 00
......	.....	1.02	1.02	0.82	1.80	6.33	2.78	10.36	....	7.63	8.00	2.39	2.00	14 12	18 00
1.46	......	2.06	3.52	3.28	4.62	3.80	1.91	10.33	....	8.42	8.00	10.10	10.00	28 95	37 00
1.08	......	2.02	3.10	3.28	3.68	5.08	1.65	10.38	....	8.71	9.00	9.89	10.00	27 69	33 00
0.51	0.21	1.53	2.25	1.64	1.80	5.28	3.22	10.30	....	7.08	7.00	6.56	3.00	21 32	26 00
1.20	......	1.47	2.67	2.46	3.94	2.69	2.07	8.70	....	6.63	8.00	10.86	10.00	25 16	31 00
0.80	......	1.71	2.51	2.46	5.10	2.94	3.30	11.34	....	8.04	11.00	4.13	3.00	20 91	28 00
0.43	......	1.42	1.85	1.64	3.58	3.56	2.27	9.41	.....	7.14	8.00	7.44	7.00	20 85	25 00
1.48	.....	1.77	3.25	3.28	3.64	6.08	1.79	11.51	....	9.72	9.00	*10.34	10.00	30 06	33 00
......	......	1.41	1.41	1.64	2.26	4.63	3.41	10.30	....	6.89	8.00	3.38	2.00	15 77	23 00
......	......	1.89	1.89	2.05	2.12	9.08	4.54	15.74	....	11.20	11.00	10.33	10.00	28 04	33 00
0.29	......	1.23	1.52	0.82	2.96	4.49	4.08	11.48	....	7.45	8.00	3.18	2.00	16 69	22 00

* Potash largely, if not entirely, in form of sulphate.

Complete Fertilizers

Furnishing Nitrogen, Phosphoric Acid and Potash.

MANUFACTURER AND BRAND.	WHERE SAMPLED.	Station Number.
The J. E. Tygert Co., Philadelphia, Pa.		
Bone Phosphate	Cedarville	2159
Fish, Bone and Potash	Dutch Neck	2472
Ten Per Cent. Sweet Potato Guano	" "	2473
Vineland Grain Co., Vineland, N. J.		
Potato Manure	Vineland	2194
Bone Phosphate	"	2195
J. K. Waddington, Salem, N. J.		
Clover Leaf Phosphate	Salem	2129
Geo. M. Wells, Moorestown, N. J.		
Prosperity Potato Manure	Moorestown	2011
Tomato and Truck Manure	"	2012
Ten Per Cent. Truck Guano	"	2013
High-Grade Potato Manure	"	2014
Fish Guano for General Use	"	2015
J. Wenderoth & Sons, Camden, N. J.		
$25-Fertilizer	Camden	2081
Ten Per Cent. Fertilizer	"	2082
Potato Fertilizer	"	2083
West Jersey Marl and Transportation Co., Woodbury, N. J.		
Our All-Crop Mixture	Fairton	2170
Our Special Sweet Potato Manure	Elmer	2164
Our Special White Potato Manure	"	2165
Bone and Potash Compounds	Fairton	2167
Our High-Grade Truck Manure	"	2169
W. E. Whann, William Penn, Pa.		
Chester Valley Sweet Potato and Celery Mixture	Cedarville	2160
Chester Valley Special Potato and Truck Fertilizer	"	2161
Young & Hoffman, White House, N. J.		
Vegetable Manure	White House	2572
†J. G. Downward & Co., Coatesville, Pa.		
Special Bone Fertilizer	Ringoes	1674
Royal Bone Phosphate	"	1675
†I. P. Thomas & Son Co., Philadelphia, Pa.		
Ammoniated Dissolved Bone and Potash	Flemington	1676
Bone and Potash	Clinton	1686
†Williams & Clark Branch, New York City.		
Potato, Hop and Tobacco Manure	Blawenburg	1680

Complete Fertilizers

Furnishing Nitrogen, Phosphoric Acid and Potash.

Nitrogen.					Phosphoric Acid.							Potash.			
From Nitrates.	From Ammonia Salts.	From Organic Matter.	Total Found.	Total Guaranteed.	Soluble in Water.	Soluble in Ammonium Citrate.	Insoluble.	Total Found.	Total Guaranteed.	Available. Found.	Available. Guaranteed.	Found.	Guaranteed.	Value of 2,000 lbs. at Station's Prices.	Selling Price of 2,000 lbs. at Consumers' Depot.
......	......	1.64	1.64	1.85	7.44	2.40	2.59	12.43	11.00	9.84	9.00	2.13	2.50	$18 10	$24 00
......	......	1.74	1.74	2.05	5.70	1.54	1.29	8.53	8.00	7.24	6.50	1.95	3.00	15 16	30 00
......	......	1.41	1.41	1.23	6.48	1.18	0.58	8.14	8.00	7.61	7.00	8.18	10.00	19 42	29 00
......	......	2.01	2.01	1.64	4.30	3.32	1.82	9.44	....	7.62	7.00	10.92	10.00	24 28	30 00
......	......	1.46	1.46	1.03	6.12	3.47	1.08	10.67	10.50	9.59	8.50	2.10	1.50	16 83	25 00
0.54	......	1.48	2.02	1.64	5.04	4.41	3.40	12.85	....	9.45	9.00	2.98	3.00	19 84	25 00
0.54	......	1.49	2.03	1.85	4.74	1.94	3.36	10.04	....	6.68	7.00	8.54	10.00	21 82	28 00
1.16	......	2.12	3.28	1.92	4.88	1.60	2.89	9.43	....	6.54	7.00	7.75	4.00	24 77	33 00
2.34	......	5.09	7.43	8.20	1.78	2.78	1.98	6.49	....	4.51	4.00	4.44	4.00	32 89	44 00
1.41	......	1.45	2.86	2.87	4.34	1.94	3.14	9.42	....	6.28	7.00	9.69	9.00	24 80	30 00
0.20	......	1.89	2.09	2.05	4.04	3.24	4.44	11.72	....	7.28	8.00	2.59	2.00	18 10	23 00
0.53	......	1.01	1.54	1.64	8.98	3.49	1.51	13.98	11.00	12.47	9.00	0.97	1.00	18 82	23 00
2.40	1.99	3.14	7.53	8.20	3.24	3.55	1.28	8.02	6.00	6.79	5.00	4.23	4.00	35 01	45 00
1.48	0.47	1.69	3.59	3.28	5.26	4.29	1.61	11.16	9.00	9.55	7.00	6.34	7.00	27 00	33 00
......	......	2.15	2.15	2.05	4.80	2.90	1.12	8.82	....	7.70	6.00	4.41	4.00	19 00	22 00
0.45	......	1.36	1.81	1.64	7.40	1.54	1.38	10.32	....	8.94	8.00	9.47	10.00	23 38	27 00
0.42	......	2.24	2.66	2.46	6.10	2.56	1.37	9.03	....	7.66	6.00	*7.88	8.00	23 77	27 00
0.44	......	1.91	2.35	1.64	2.34	6.01	3.33	11.68	....	8.35	8.50	3.88	3.00	20 60	24 00
0.75	......	2.44	3.19	3.28	6.36	3.44	1.59	10.39	....	8.80	8.00	7.91	7.00	26 46	31 00
......	......	0.96	0.96	0.82	5.02	2.25	0.94	8.21	....	7.27	7.00	14.35	15.00	23 02	28 00
1.58	......	1.15	2.73	2.46	5.18	1.57	0.92	7.67	10.00	6.75	7.00	6.66	7.00	21 32	28 00
......	......	1.92	1.92	1.64	3.70	7.52	0.57	11.79	....	11.22	8.00	4.04	4.00	21 22	24 00
......	......	1.07	1.07	1.23	3.50	3.90	1.81	9.21	9.00	7.40	7.00	2.98	2.50	13 99	24 00
......	......	0.96	0.96	0.82	3.54	4.48	1.86	9.88	9.00	8.02	8.00	2.89	2.00	14 29	22 00
......	......	1.29	1.29	0.82	6.94	2.70	2.20	11.84	11.00	9.64	9.00	1.49	4.00	15 92	25 00
......	......	1.59	1.59	......	4.66	6.54	5.85	17.05	....	11.20	....	2.18	....	20 48	25 00
0.47	0.44	1.26	2.17	2.05	5.42	4.11	2.17	11.70	....	9.53	8.00	2.97	3.00	19 77	19 15

Ground Bone

Furnishing Nitrogen and Phosphoric Acid.

Station Number.	BRAND.	MANUFACTURER.
2882	Pure Ground Bone	Allentown Manufacturing Co., Allentown, Pa
2488	Clark's Cove Fine Ground Bone	American Agricultural Chemical Co., N. Y. City
2583	Great Eastern Fine Ground Bone	" " " " " "
2742	Williams & Clark's Fine Ground Bone	" " " " " "
2479	Bone Meal	Armour Fertilizer Works, Baltimore, Md
2482	Raw Bone, Fine	The Berg Co., Philadelphia, Pa
2646	Fresh Ground Bone	Bowker Fertilizer Co., Boston, Mass
2024	Pure Steamed Bone, No. 1	J. S. Collins & Son, Moorestown, N. J
2025	Pure Steamed Bone, No. 2	" " " "
2401	Pure Ground Bone	Collins & Pancoast, Merchantville, N. J
2692	Pure Bone Dust	Peter Cooper's Glue Factory, New York City
2410	Pure Raw Bone	Wyckoff Hendrickson, Allentown, N. J
2515	Pure Ground Bone	Ira Hill, Copper Hill, N. J
2284	Pure Ground Bone	Hires & Co., Quinton, N. J
2561	Warranted Pure Ground Bone	Lackawanna Fertilizer and Chemical Co., Moosic, Pa
2589	Pure Ground Bone	Samuel Lederer & Son, New Brunswick, N. J
2637	Pure Raw Bone Meal	Lister's Agricultural Chemical Works, Newark, N. J
2257	Bone Meal	John E. Minch, Bridgeton, N. J
2265	Button Bone Dust	L. Moritz, Philadelphia, Pa
2443	Russell's Ground Bone	New Jersey Agricultural Chemical Co., Newark, N. J
2632	Ground Bone	Ruckman Bros., New Brunswick, N. J
2288	Swift-Sure Bone Meal	M. L. Shoemaker & Co., Philadelphia, Pa
2186	Pure Ground Bone	Somerset Chemical Co., Bound Brook, N. J
2849	Ground Bone	Taylor Provision Co., Trenton, N. J
2128	Button Bone Dust	Emil Wahl Manufacturing Co., Philadelphia, Pa
2217	Bone Sawings	Winterbottom, Carter & Co., Egg Harbor City, N. J

Ground Bone

Furnishing Nitrogen and Phosphoric Acid.

WHERE SAMPLED.	Station Number.	Mechanical Analysis.		Chemical Analysis.		Value of 2,000 lbs. at Station's Prices.	Selling Price of 2,000 lbs. at Consumers' Depot.
		Finer than 1-50th in.	Coarser than 1-50th in.	Nitrogen.	Phosphoric Acid.		
Morristown	2682	60	40	4.06	28.76	$28 77	$32 00
Flemington	2483	50	50	2.20	29.44	26 77	26 00
Basking Ridge	2583	53	47	2.31	29.82	27 22	28 00
Flemington	2712	58	42	1.89	25.82	23 53	24 00
Lambertville	2479	62	38	2.44	25.64	25 62	26 00
Stockton	2482	41	59	4.01	24.28	27 50	26 00
Montclair	2646	53	47	2.64	26.26	26 00	35 00
Moorestown	2024	69	31	2.47	24.86	25 64	25 00
"	2025	55	45	1.28	28.60	23 93	23 00
Haddon Heights	2401	45	55	4.10	22.98	27 17	23 50
Morristown	2692	52	48	1.47	29.64	25 00	24 00
Allentown	2410	39	61	3.89	22.48	25 80	27 00
Copper Hill	2515	49	51	4.01	20.80	25 71	27 00
Quinton	2284	68	32	2.80	27.68	27 15	26 00
Potterstown	2561	44	56	4.18	24.06	27 91	28 00
Neshanic	2589	47	53	2.58	26.34	25 44	30 00
Flemington	2637	51	49	2.91	26.04	26 45	27 00
Bridgeton	2267	69	31	3.94	21.44	27 45	28 00
"	2266	89	11	2.75	25.40	28 32	28 00
Hopewell	2443	33	67	3.40	22.74	24 19	28 00
New Brunswick	2632	60	40	2.56	26.92	26 58	25 00
Quinton	2288	63	37	4.87	25.68	32 78	30 00
Vineland	2186	41	59	3.86	21.82	25 41	26 00
Cranbury	2349	65	35	2.22	27.10	26 27	25 50
Woodstown	2128	64	36	3.89	24.68	27 99	26 00
Egg Harbor City	2217	96	4	3.79	27.02	33 41	27 00

Miscellaneous Fertilizers

Furnishing Phosphoric Acid and Nitrogen or Potash.

MANUFACTURER AND BRAND.	WHERE SAMPLED.	Station Number.
Armour Fertilizer Works, Baltimore, Md.		
Phosphate and Potash, No. 1	Lambertville	2480
Star Phosphate	Hackettstown	2703
American Agricultural Chem. Co., New York City.		
Chicopee Harvest Favorite	Westwood	2668
Clark's Cove Atlas Bone Phosphate	Flemington	2484
Great Eastern Soluble Bone and Potash	Basking Ridge	2582
Pacific Dissolved Bone and Potash	Hightstown	2395
Packers' Union Acidulated Bone	Mt. Ephraim	2055
Quinnipiac Dissolved Bone and Potash	Washington	2715
Quinnipiac Soluble Dissolved Bone	Everittstown	2497
Read's Alkaline Bone	Chester	2716
Williams & Clark's Dissolved Bone and Potash	Millstone	2619
Bowker Fertilizer Co., Boston, Mass.		
Superphosphate with Potash	New Germantown	2556
E. Frank Coe Co., New York City.		
High-Grade Dissolved Bone and Potash	Skillman	2454
S. M. Hess & Bro., Philadelphia, Pa.		
Soluble Bone and Potash	Ringoes	2511
Lackawanna Fertilizer and Chem. Co., Moosic, Pa.		
Alkaline Bone	Baptistown	2489
Lister's Agricultural Chemical Works, Newark, N. J.		
Animal Bone and Potash, No. 2	Red Bank	2317
Alkaline Bone	Lebanon	2557
R. H. Pollock, Baltimore, Md.		
Victor Bone Phosphate	Milford	2546
Lester Shurts, Neshanic Station, N. J.		
Corn and Oats Fertilizer	Neshanic Station	2563
Rufus W. Smith, Elmer, N. J.		
Superior Fertilizer	Elmer	2152
Somerset Chemical Co., Bound Brook, N. J.		
Degelatinized Bone	Moorestown	2577
I. P. Thomas & Son Co., Philadelphia, Pa.		
Special Alkaline Bone	Titusville	2465
Alkaline Bone	"	2467
Improved Animal Bone	"	2471
Improved Animal Bone	Freehold	2752
Special Dissolved Bone and Potash	White House	2569
Oak Leaf Phosphate	" "	2570
Trenton Bone Fertilizer Co., Trenton, N. J.		
Dissolved Tankage	Newton	2734

Miscellaneous Fertilizers

Furnishing Phosphoric Acid and Nitrogen or Potash.

Nitrogen.					Phosphoric Acid.							Potash.			
										Available.					
From Nitrates.	From Ammonia Salts.	From Organic Matter.	Total Found.	Total Guaranteed.	Soluble in Water.	Soluble in Amonium Citrate.	Insoluble.	Total Found.	Total Guaranteed.	Found.	Guaranteed.	Found.	Guaranteed.	Value of 2,000 lbs. at Station's Prices.	Selling Price of 2,000 lbs. at Consumers' Depot.
.....	.....	.....	.....	.....	8.60	1.54	1.12	11.26	12.00	10.14	10.00	2.11	2.00	$12 38	$17 00
.....	.....	.....	.....	.....	13.04	1.08	0.80	14.42	16.00	14.12	14.00	.....	.....	†5.7	16 00
.....	.....	.....	.....	.....	9.24	8.37	1.61	14.22	13.00	12.61	12.00	.....	.....	†7.1	18 00
.....	.....	.....	.....	.....	11.84	2.40	2.02	16.26	15.00	14.24	14.00	.....	.....	†4.2	12 00
.....	.....	.....	.....	.....	5.56	8.98	2.29	11.83	11.00	9.54	10.00	2.49	2.00	12 58	18 00
.....	.....	.....	.....	.....	4.80	5.56	2.56	12.42	11.00	9.86	10.00	2.24	2.00	12 78	18 00
.....	.....	.....	.....	.....	10.84	2.96	1.49	15.29	15.00	13.80	14.00	.....	.....	†5.1	14 00
.....	.....	.....	.....	.....	8.72	6.46	2.02	12.20	11.00	10.18	10.00	2.05	2.00	12 73	18 00
.....	.....	.....	.....	.....	10.80	2.43	2.48	15.66	15.00	13.23	14.00	.....	.....	†5.3	14 00
.....	.....	.....	.....	.....	6.30	3.82	* 2.58	12.70	11.00	10.12	10.00	3.28	2.00	13 94	18 00
.....	.....	.....	.....	.....	4.06	5.84	2.68	12.58	11.00	9.90	10.00	2.24	2.00	12 87	15 00
.....	.....	.....	.....	.....	5.24	5.09	2.51	12.84	12.00	10.33	10.00	1.25	1.00	12 39	13 50
.....	.....	.....	.....	.....	6.28	3.81	3.85	13.94	12.50	10.09	10.50	1.82	2.00	13 18	20 00
.....	.....	.....	.....	.....	4.86	6.18	1.86	11.90	11.00	10.54	10.00	2.17	2.00	12 93	19 00
.....	.....	.....	.....	.....	6.16	1.61	0.37	8.14	10.00	7.77	8.00	1.71	1.62	9 37	16 00
.....	.....	.....	.....	.....	7.28	2.66	2.54	12.48	11.00	9.94	10.00	1.79	2.00	12 48	22 00
.....	.....	.....	.....	.....	7.48	2.34	1.48	11.30	.....	9.82	10.00	*1.78	2.00	12 19	15 00
.....	.....	.....	.....	.....	2.00	6.50	1.57	10.07	10.00	8.50	9.00	1.37	1.00	10 30	16 50
.....	.....	.....	.....	.....	10.06	2.66	2.28	15.00	13.00	12.72	12.00	3.26	3.00	16 40	18 00
.....	.....	.....	.....	.....	1.72	7.31	2.08	11.06	12.00	9.03	10.00	2.08	2.00	11 61	14 00
.....	.....	1.14	1.14	1.23	0.08	15.74	13.50	29.32	24.75	15.82	.....	.....	.....	24 98	18 25
.....	.....	.....	.....	.....	3.98	6.50	1.48	11.96	12.00	10.48	10.00	4.43	4.00	14 84	25 00
.....	.....	.....	.....	.....	6.30	4.23	1.53	12.06	12.00	10.53	10.00	2.53	2.00	13 29	25 00
.....	.....	1.10	1.10	1.64	6.02	5.29	8.50	19.81	20.00	11.31	.....	.....	.....	18 34	26 00
.....	.....	1.81	1.81	1.64	6.50	5.04	6.83	18.37	.....	11.54	10.00	.....	.....	20 24	21 00
.....	.....	.....	.....	.....	8.64	3.20	0.93	12.77	12.00	11.84	10.00	3.28	2.00	15 00	20 00
.....	.....	.....	.....	.....	1.20	8.34	4.00	13.54	14.00	9.54	12.00	.....	.....	†6.8	13 00
.....	0.25	3.29	3.54	4.10	5.90	6.20	0.40	12.50	11.00	12.10	10.00	.....	.....	23 95	0 00

* Potash largely, if not entirely, in form of sulphate. † Cost per pound in cents of available hosphoric acid.

Sundry Materials.

2008. Lime Kiln Ashes. Made by White Rock Lime Co. McAfee, N. J. Sent by Nelson Crissey, Glenwood.

2132. Canada Wood Ashes. Made by John Joynt, Luck now, Ontario, Canada. Sent by W. M. Brown, Cedarville. Ligh sample.

2133. Canada Wood Ashes. Made by John Joynt, Luck now, Ontario, Canada. Sent by W. M. Brown, Cedarville. Dar sample.

2743. Canada Wood Ashes. Made by John Joynt, Luck now, Ontario, Canada. Sent by G. H. Dobbs, Bernardsville.

2747. Canada Wood Ashes. Sold by Bowker Fertilize Co., Boston, Mass. Sent by P. J. Staats, Bound Brook.

2578. Prepared Lime. Made by G. & W. H. Corson Plymouth Meeting, Pa. Sent by College Farm.

2680. Prepared Lime and Potash. Made by G. & W H. Corson, Plymouth Meeting, Pa. Sent by College Farm.

2681. Oyster Shell Lime. Made by R. R. Outcalt, New Brunswick, N. J. Sent by College Farm.

2750. Blue Lime. Made by Wrightsville Lime Co., Wrights ville, Pa. Sent by W. Y. Holt, Flemington, N. J.

	2008	2132	2133	2743	2747	2578	2680	2681	275
	%	%	%	%	%	%	%	%	%
Phosphoric Acid	1.83	2.13	1.48	1.02	1.60	....	....	0.06	......
Potash	1.59	6.59	5.76	4.50	3.84	....	3.57	....	.....
Lime	44.92	42.56	37.14	37.42	31.87	43.76	41.38	75.28	54.[illegible]
Valuation per ton	$2.65	$8.29	$6.94	$5.32	$5.12	....	$3.03	....	.....
Selling price per ton	*	$10.75	$10.75	$10.50	$10.50	$11.00	....	$4.80	$7.[illegible]

* 15 cts. per bushel.

2001. Tannery Refuse. Sediment after hides are scoure with potash, etc. Sent by Samuel DeCou, West Moorestown.

2002. Tannery Refuse. Inner coatings of hides scraped o by machinery. Sent by Samuel DeCou, West Moorestown.

2003. Tannery Refuse. Lime and hair. Sent by Samu DeCou, West Moorestown.

2016. Garbage Ashes. From crematory at Trenton, N. J Sent by Bruno Pollman, Trenton.

2196. Oil Cake Waste. From oil cake meal bags. Sent b E. S. Dobbs, Mount Ephraim.

2197. Wool Waste. Sent by E. S. Dobbs, Mount Ephraim

2398. Soot. From linoleum works. Sent by H. I. Budd, Mount Holly.

	2001	2002	2003	2016	2196	2197	2398
	%	%	%	%	%	%	%
Nitrogen	1.70	12.98	1.45	0.89	6.78	2.79	0.48
Phosphoric Acid	1.68	0.19	0.38	2.22	1.01	0.83	0.20
Potash	0.06	0.27	0.16	1.47	0.66	8.20	0.22
Selling price per ton	......	.....	......	$3.00	$5.00	$2.50	......

106. Bone Residue. Made by Somerset Chemical Co., Bound Brook, N. J. It contains a trace of nitrogen, 0.52 per cent. soluble, 33.28 per cent. reverted, 2.26 per cent. insoluble, and 36.06 per cent. total phosphoric acid.

2007. Unnamed Fertilizer. Made by Kirkwood Marl Co., Kirkwood, N. J. Sent by C. T. DeCou, Ellisburg. Selling price, $22.50 per ton ; valuation, $6.32. It contains 0.70 per cent. nitrogen, 4.94 per cent. total and 2.94 per cent. available phosphoric acid and 0.32 per cent. potash.

2426. Tobacco Stems. Made in Reading, Pa. Sent by G. A. Mitchell, Vineland. It contains 0.43 per cent. nitric and 2.37 per cent. organic nitrogen, 0.65 per cent. phosphoric acid, and 5.54 per cent. potash. Selling price, $10 per ton.

2296. Bat Guano. From deposits near Uvalde, Texas. Sent by F. F. Babcock, New Brunswick. It contains 2.79 per cent. nitrates, 2.63 per cent. ammoniacal nitrogen, 6.34 per cent. organic nitrogen, 1.72 per cent. soluble, 1.68 per cent. reverted, and 0.24 per cent. insoluble phosphoric acid and 1.20 per cent. potash.

Average Analyses of Fertilizing Materials.

Since the establishment of this Station a large number of analyses have been made of agricultural chemicals, refuse materials, guanos, phosphates, ashes, animal excrement, etc. These have been published from time to time in the Annual Reports, but for convenience of reference they are now collected here. In the tables which follow will be found the average, and, where more than one analysis has been made, the maximum and minimum percentages found of the essential plant-food ingredients, nitrogen, phosphoric acid and potash. Where determined, the form of the nitrogen and the phosphoric acid is also shown. While in all cases the essential ingredients have been determined and are here reported, a blank under any non-essential does not necessarily imply the absence of that constituent. In addition to the materials sold regularly for fertilizing purposes, the tables contain a number of analyses of fruit leaves, fruit tree prunings, and the vines of several of the more important vegetables.

The tables include 156 different materials, and represent 2,687 analyses :

Number of analyses.	FERTILIZING MATERIAL.	Moisture.	NITROGEN.			PHOSPHORIC ACID.		
			Maximum.	Minimum.	Average.	Maximum.	Minimum.	Average.
1	Alcohol waste, wood							0.04
114	Ammonia, sulphate of		21.20	16.26	20.45			
27	Ammonite		14.21	10.07	11.88	4.68	1.17	3.02
1	Ashes, apple pomace							6.80
5	Ashes, cottonseed hull					10.76	7.92	9 59
2	Ashes, crematory					15.39	6.70	11.05
1	Ashes, hemlock							2.05
1	Ashes, hickory							1.63
1	Ashes, licorice root							0.76
3	Ashes, lime kiln					1.64	1.13	1.37
1	Ashes, muck							7.74
1	Ashes oak							2.42
5	Ashes, leached wood					1.88	0.15	0.74
69	Ashes, unleached wood					2.48	0.91	1.61
8	Basic slag					20.48	17.81	19.14
89	Blood, dried		14.58	7.81	12.07	3.98	0.00	0.52
1	Blood, meat and bone				2.23			22.97
3	Bone ash					18.18	17.18	17.82
29	Bone, button		4.36	2.75	3.61	27.02	23.67	24.95
3	Bone, degelatinized		1.33	1.14	1.22	29.32	27.22	28.37
54	Bone, dissolved		4.18	1.32	2.61	21.90	10.97	16.44
458	Bone, raw ground		6.98	1.18	3.67	28.65	11.10	22.52
1	Bone residue				0.09			36.06
52	Bone, steamed		3.35	0.74	2.02	32.86	24.24	28.44
2	Bone and meat		2.17	1.90	2.04	11.67	6.40	9.04
1	Broom-corn seed	8.88			1.71			0.72
7	Castor pomace		6.19	4.15	5.44	2.20	1.73	1.99
1	Clay, nitrate-bearing	3.40			1.00			0.16
2	Corena settlings		2.36	0.14	1.25	1.28	0.79	1.04
1	Cottonseed hulls				0.69			0.56
90	Cottonseed meal	7.60	7.58	3.81	6.34	4.77	1.71	2.93
1	Cracklings				13.22			
1	Feather refuse				14.76			
12	Fish, crude		6.47	3.94	4.87	6.04	3.68	5.23
187	Fish, dried		11.40	4.36	7.98	12.31	3.19	7.23
4	Floats					42.40	26.44	36.59
1	Flue dust				0.08			1.25
2	Garbage refuse		0.39	0.00	0.20	2.22	2.07	2.15
1	Guano, bat, California, dried				1.90			17.14
1	Guano, bat, Mexico				2.77			5.24
1	Guano, bat, Texas				11.76			3.64
1	Guano, Carib							18.92

Potash.			Nitrogen.			Phosphoric acid.					
Maximum.	Minimum.	Average.	Nitrates.	Ammonia.	Organic.	Soluble.	Reverted.	Insoluble.	Lime.	Magnesia.	Sulphuric acid.
		0.06							41.54		
				20.45							
					11.86						
		11.88									
30.40	20.52	26.55				1.40	6.61	1.58			
2.08	1.81	1.95							22.00		
		3.67							54.52		
		4.56							36.29		
		0.07							28.00		
3.61	0.54	1.92							41.47		
		0.22					1.02	6.72	0.34		
		9.87							29.65		
1.89	0.16	0.69							28.75		
3.81	2.17	5.02							33.04		
							5.45	13.69			
					12.07						
					2.28	0.26	8.84	15.87			
						16.75	0.75	0.82			
				*	8.61		6.81	18.64			
				0.46	0.76		15.30	13.07			
					2.61	6.06	6.22	4.16			
					3.67		7.69	14.88			
					0.09	0.52	33.28	2.26			
					2.02		7.51	20.98			
					2.04	6.78	0.90	1.86			
		0.52			1.71						
					5.44						
	*	0.18	1.00						12.78		
0.62	0.00	0.31			1.25						
		1.08			0.69						
2.80	1.68	0.81			6.34						
					18.22						
					14.76						
					4.87						
					7.98						
							2.08	84.51			
					0.06		0.25	1.00			
1.47	1.17	1.82			0.20				7.92		
		6.27		0.29	1.61	3.04	9.62	4.48			
		0.52	2.03		0.74		2.47	2.77			
		1.20	2.79	2.68	6.84	1.72	1.68	0.24			
							1.41	17.51			

Number of analyses.	FERTILIZING MATERIAL.	Moisture.	Nitrogen.			Phosphoric Acid.		
			Maximum.	Minimum.	Average.	Maximum.	Minimum.	Average.
1	Guano, Cayman Island	....	....	....	....	....	....	25.91
7	Guano, Orchilla	....	....	....	....	19.34	15.70	17.01
1	Guano, Penguin Island	....	....	....	....	....	....	21.80
7	Guano, Peruvian	....	7.45	4.28	5.86	16.88	11.00	13.95
8	Hair waste	....	10.48	2.91	6.01	4.49	0.52	2.27
1	Hemp waste	....	....	....	0.57	....	....	0.12
5	Hoof meal	....	15.11	12.52	13.72	....	....	0.18
1	Horn meal	....	....	....	14.86	....	....	Trace
2	Horse meat	....	8.87	7.69	8.28	4.37	4.25	4.31
1	Iron tailings	....	....	....	....	....	....	25.95
d24	Kainit	....	....	....	....	....	....	....
1	Kiln dust	....	....	....	4 46	....	....	1.55
12	King crab	....	10.56	8.09	9.47	2.08	0.92	1.18
8	Leather, raw	....	7.56	7.50	7.54	....	....	....
1	Leather, steamed	....	....	....	6.87	....	....	....
1	Leather, treated	....	....	....	7.22	....	....	....
4	Leaves, apple	59.32	1.07	0.95	1.01	0.21	0.17	0.18
4	Leaves, cherry	61.20	0.82	0.55	0.70	0.17	0 10	0.18
4	Leaves, peach	63.64	1.40	1.22	1.32	0.26	0.19	0.23
8	Leaves, pear	47.94	1.21	0.78	0.92	0.21	0.16	0.18
8	Leaves, plum	60.46	1.16	0.76	0.91	0.27	0.15	0.19
3	Leaves, quince	61.02	0.91	0.58	0.79	0.19	0.10	0.16
1	Licorice residue	56.07	....	....	0.69	....	....	....
1	Lime, blue	....	....	....	....	....	....	....
1	Lime, gas	....	....	....	0.59	....	....	....
2	Lime, marble	....	....	....	....	....	....	....
1	Lime, prec. carbonate of	....	....	....	....	....	....	....
4	Lime, prec. phosphate of	....	....	....	....	33.27	22.89	28.88
1	Lime, prepared	....	....	....	....	....	....	....
1	Lime, prepared, and potash	....	....	....	....	....	....	....
1	Lime, saltpetre	....	....	....	....	....	....	0.10
2	Lime sand	10.88	....	....	....	....	....	....
2	Lime, oyster shell	....	....	....	....	....	....	0 06
1	Lime, soft-clam shell	....	....	....	....	....	....	0.10
5	Lime, slaked	....	....	....	....	....	....	....
2	Lime, stone	....	....	....	....	....	....	....
1	Lime, Wonder	....	....	....	....	....	....	1.64
1	Linseed cake waste	....	....	....	6.78	....	....	1.01
22	Linseed meal	9.46	6.45	5.18	5.59	2.37	1.39	1.97
1	Manure, Belgian hare	50.94	....	....	1.10	....	....	0.58
11	Manure, cow, solid fresh	84.93	0.48	0.29	0.35	0.43	0.27	0.33
11	Manure cow, solid and liquid, fresh	86.31	0.54	0.26	0.46	0.41	0.21	0.30

POTASH.			NITROGEN.			PHOSPHORIC ACID.					
Maximum.	Minimum.	Average.	Nitrates.	Ammonia.	Organic.	Soluble.	Reverted.	Insoluble.	Lime.	Magnesia.	Sulphuric acid.
							2 80	28.11			
							5.73	11.28			
8 34	0.40	2.02		4.33	1.53	8.28	3.70	6.97			
0.17	0.13	0.15			6.01						
		0 19			0.57						
					18.72						
					14.85						
					8.28						
							1.18	24.77			
14.08	10.89	12.55									
		2.52			4.46						
					9.47						
					7.54						
					6.87						
					7.22						
0.82	0.66	0.75			1.01						
0.62	0.44	0.56			0.70						
0.79	0.48	0.69			1.32						
0.86	0.51	0.64			0.92						
1.28	0.67	0.95			0.91						
0.91	0.44	0.70			0.79						
					0.69						
									54.09		
				0.59					38.54		
									71.82	8.88	
									51.20		
							26.87	2.01			
									48.76		
		3.57							41.88		
									80.64		
									23.04	1.16	
									75.19		
									50.52		
									52.78	27.13	
									27.89	19.63	
		0.62					0.46	1.18	48.92		
		0.66			6.78						
1.59	0.64	1.36			5.59						
		0.58						0.08	1.01		
0.29	0.13	0.21	0.01	0.08	0.81						
0.78	0.20	0.38	0.01	0.11	0.84						

Number of analyses.	FERTILIZING MATERIAL.	Moisture.	NITROGEN.			PHOSPHORIC ACID.		
			Maximum.	Minimum.	Average.	Maximum.	Minimum.	Average.
5	Manure, cow, solid leached	78.79	0.60	0.41	0.47	0.50	0.28	0.39
5	Manure, cow, solid and liquid leached	80.71	0.68	0.34	0.50	0.51	0.25	0.40
1	Manure, duck	....	....	....	0.67	....	....	0.80
3	Manure, hen	57.60	1.23	0.78	1.04	1.12	0.46	0.83
3	Manure, pigeon	57.66	4.06	1.34	2.29	2.67	0.82	1.60
35	Marl	....	....	....	....	3.94	0.25	1.11
1	Marl, shell	....	....	....	....	....	....	0.19
11	Muck	59.21	1.89	0.19	0.58	0.87	0.08	0.27
2	Muck, dried	....	1.45	1.24	1.35	0.56	0.40	0.48
1	Mussels	68.19	....	....	0.90	....	....	0.12
1	Peanut pulp	....	....	....	8.52	....	....	0.52
1	Phosphoral	....	....	....	....	....	....	49.40
1	Phosphorus works refuse	....	....	....	0.14	....	....	1.27
2	Plaster, Cayuga	18.26	....	....	....	....	....	....
11	Plaster, Nova Scotia	19.90	....	....	....	....	....	....
1	Plaster, Nova Scotia, calcined	....	....	....	....	....	....	....
2	Plaster, Onondaga	17.10	....	....	....	....	....	....
1	Porpoise scrap	....	....	....	12.00	....	....	0.64
9	Potash, bisulphate of	....	....	....	....	....	....	....
48	Potash, double sulphate of	....	....	....	....	....	....	....
52	Potash, high-grade sulphate of	....	....	....	....	....	....	....
286	Potash, muriate of	....	....	....	....	....	....	....
1	Potash, nitrate of, from tobacco extract	....	....	....	10.41	....	....	....
1	Potash, phosphate of	....	....	....	....	....	....	42.17
2	Potash, prussiate of, waste	....	....	....	....	1.08	0.40	0.74
11	Poudrette	....	1.83	0.44	1.24	4.74	1.91	3.34
2	Prunings, apple	53.58	0.34	0.29	0.32	0.13	0.10	0.12
2	Prunings, cherry	52.24	0.31	0.28	0.30	0.13	0.10	0.12
1	Prunings, grape-vine	43.61	....	....	0.36	....	....	0.12
3	Prunings, peach	49.40	0.65	0.44	0.52	0.14	0.13	0.14
4	Prunings, pear	50.87	0.45	0.39	0.43	0.18	0.16	0.17
6	Prunings, plum	47.68	0.53	0.23	0.36	0.21	0.10	0.14
2	Prunings, quince	49.18	0.42	0.31	0.37	0.13	0.09	0.11
1	Saltpetre waste	....	....	....	0.35	....	....	....
1	Sea pumpkin	7.29	....	....	1.47	....	....	0.60
1	Sewage, East Orange	57.18	....	....	0.52	....	....	0.27
1	Slug, ground (horn pith)	....	....	....	4.79	....	....	15.69
199	Soda, nitrate of	....	16.44	14.22	15.89	....	....	....
2	Soot	....	0.48	0.18	0.33	0.78	0.20	0.49
1	Street sweepings	....	....	....	0.18	....	....	0.80
1	Sturgeon, dried	5.52	....	....	4.45	....	....	12.57

Potash.			Nitrogen.			Phosphoric acid.					
Maximum.	Minimum.	Average.	Nitrates.	Ammonia.	Organic.	Soluble.	Reverted.	Insoluble.	Lime.	Magnesia.	Sulphuric acid.
0.35	0.14	0.23	…	0.02	0.45	…	…	…	…	…	…
0.80	0.22	0.48	…	0.07	0.43	…	…	…	…	…	…
…	…	0.34	…	…	0.67	…	…	0.01	…	…	…
0.45	0.36	0.42	…	0.34	0.70	…	…	0.15	2.51	…	…
1.57	0.48	0.96	…	…	2.29	…	…	0.20	2.78	…	…
0.86	0.00	0 33	…	…	…	…	…	…	2.89	…	…
…	…	0.06	…	…	…	…	…	…	30.00	…	…
0.23	0.06	0.16	…	…	0.58	…	…	…	0 15	…	…
0.22	0.07	0.15	…	…	1.35	…	…	…	0.56	…	…
…	…	0.18	…	…	0.90	…	…	…	15.84	…	…
…	…	1.21	…	…	8.52	0.26	0.26	…	…	…	…
…	…	…	…	…	…	…	4.61	44.79	…	…	…
…	…	0.28	…	…	0.14	0.63	0.34	0.30	…	…	…
…	…	…	…	…	…	…	…	…	20.61	…	29.48
…	…	…	…	…	…	…	…	…	31.01	…	44.17
…	…	…	…	…	…	…	…	…	39.54	…	56.46
…	…	…	…	…	…	…	…	…	26.67	…	88.08
…	…	…	…	…	12.00	…	…	…	…	…	…
36.91	30.05	34.17	…	…	…	…	…	…	…	…	…
28.56	21.35	25.47	…	…	…	…	…	…	…	…	…
58.47	42.78	49.48	…	…	…	…	…	…	…	…	…
59.32	42.34	51.17	…	…	…	…	…	…	…	…	…
…	…	40.78	9.94	…	0.47	…	…	…	…	…	…
…	…	49.96	…	…	…	…	…	…	…	…	…
7.47	4.94	6.21	…	…	…	…	…	…	…	…	…
1.87	0.16	0.46	0.06	0.24	0.94	0.47	2.37	0.50	…	…	…
0.20	0.18	0.19	…	…	0.82	…	…	…	…	…	…
0.17	0.12	0.15	…	…	0.30	…	…	…	…	…	…
…	…	0.37	…	…	0.36	…	…	…	…	…	…
0.29	0.21	0.24	…	…	0.52	…	…	…	…	…	…
0.28	0.15	0.24	…	…	0.48	…	…	…	…	…	…
0.27	0.16	0.21	…	…	0.36	…	…	…	…	…	…
0.31	0.27	0.29	…	…	0.37	…	…	…	…	…	…
…	…	1.02	0.35	…	…	…	…	…	…	…	…
…	…	0.37	…	…	1.47	…	…	…	…	…	…
…	…	0.10	…	…	0.52	…	…	…	11.06	…	…
…	…	…	…	…	4.79	…	…	…	…	…	…
…	…	…	15.89	…	…	…	…	…	…	…	…
0.25	0.22	0.24	…	…	0.33	…	…	…	…	…	…
…	…	0.19	…	…	0.18	…	…	…	…	…	…
…	…	…	…	…	4.45	…	…	…	…	…	…

Number of analyses.	FERTILIZING MATERIAL.	Moisture.	NITROGEN. Maximum.	NITROGEN. Minimum.	NITROGEN. Average.	PHOSPHORIC ACID. Maximum.	PHOSPHORIC ACID. Minimum.	PHOSPHORIC ACID. Average.
120	Superphosphate, bone-black	....	....	....	....	21.58	18.84	16.93
17	Superphosphate, double	....	....	....	....	45.82	81.68	40.48
7	Superphosphate, English	....	....	....	....	20 92	14.06	16.87
261	Superphosphate, S. C. rock	....	....	....	....	20.96	11.29	15.92
1	Sylvinit	....	....	....	....	....	....	....
92	Tankage	....	9.12	2.95	6.28	22.84	2.31	12.00
2	Tankage, beef	....	4.34	8.85	3.85	19.97	10.11	15.04
1	Tankage, concentrated	....	....	....	11.13	....	....	0.69
4	Tankage, dissolved	....	5.02	2.97	3.98	12.50	10.53	11.44
8	Tankage, garbage	11 50	2.95	0.64	2.03	8.15	1.65	2.22
4	Tankage, hog	....	7.00	4.90	6.02	18.91	10.01	14.58
1	Tannery refuse, sediment	....	....	....	1.70	....	....	1.68
1	Tannery refuse, hide coatings	....	....	....	12.98	....	....	0.19
1	Tannery refuse, lime and hair	....	....	....	1.45	....	....	0.38
5	Texana manure	....	0.98	0.69	0.82	5.70	4.00	4.91
4	Tobacco dust	....	2.53	1.03	1.50	0.56	0.32	0.39
1	Tobacco leaf	....	....	....	3.18	....	....	0.32
7	Tobacco stems	....	2.89	1.70	2.37	1.11	0.51	0.70
2	Tobacco and sulphur	....	2.42	2.35	2.39	0.91	0.88	0.90
1	Tomato pomace	....	....	....	0.42	....	....	0.11
23	Tops, asparagus	59.93	1.06	0.41	0.67	0.22	0.06	0.13
4	Vines, bean	78.33	0.72	0.59	0.66	0.19	0.15	0.18
7	Vines, pea	69.56	1.00	0.39	0.67	0.31	0.11	0 19
1	Vines, sweet potato, red	17.20	....	....	1.69	....	....	0.44
1	Vines, sweet potato, yellow	13.10	....	....	2.46	....	....	0.60
6	Vines, tomato	37.19	0.96	0.83	0.88	0.49	0.31	0.38
1	Waste, household, animal	58.70	....	....	1.64	....	....	2.74
1	Waste, household, vegetable	84.46	....	....	0.30	....	....	0.12
1	Wool combings	....	....	....	10.80	....	....	0.15
4	Woolen waste	....	7.96	6.66	7.36	0.44	0.05	0.25
12	Wool waste	....	3.27	2.00	2.57	0.62	0.11	0.40

Potash.			Nitrogen.			Phosphoric acid.					
Maximum.	Minimum.	Average.	Nitrates.	Ammonia.	Organic.	Soluble.	Reverted.	Insoluble.	Lime.	Magnesia.	Sulphuric acid.
…	…	…	…	…	…	15.52	0.88	0.58	…	…	…
…	…	…	…	…	…	34.96	4.08	1.49	…	…	…
…	…	…	…	…	…	14.41	0.72	1.24	…	…	…
…	…	…	…	…	…	10.17	2.68	3.07	…	…	…
…	…	4.83	…	…	…	…	…	…	…	…	…
…	…	…	…	…	6.28	…	…	…	…	…	…
…	…	…	…	…	3.85	…	…	…	…	…	…
…	…	…	…	…	11.13	…	…	…	…	…	…
…	…	…	…	…	…	7.19	3.54	0.71	…	…	…
1.36	0.61	0.91	…	…	2.03	…	…	…	7.51	…	…
…	…	…	…	…	6.02	…	…	…	…	…	…
…	…	0.06	…	…	1.70	…	…	…	…	…	…
…	…	0.27	…	…	12.98	…	…	…	…	…	…
…	…	0.16	…	…	1.45	…	…	…	…	…	…
1.00	0.56	0.76	0.31	…	0.51	0.67	1.65	2.59	…	…	…
2.20	1.01	1.37	0.20	…	1.30	…	…	…	…	…	…
…	…	1.70	1.45	…	1.78	…	…	…	…	…	…
9.76	4.91	6.68	0.69	…	1.68	…	…	…	…	…	…
7.86	6.78	7.32	0.82	…	1.57	…	…	…	…	…	*0.91
…	…	0.18	…	…	0.42	…	…	…	…	…	…
1.16	0.57	0.82	…	…	0.67	…	…	…	…	…	…
0.57	0.40	0.51	…	…	0.66	…	…	…	…	…	…
1.10	0.30	0.61	…	…	0.67	…	…	…	…	…	…
…	…	1.44	…	…	1.69	…	…	…	…	…	…
…	…	1.69	…	…	2.46	…	…	…	…	…	…
0.49	0.19	0.37	…	…	0.88	…	…	…	…	…	…
…	…	0.30	…	…	1.64	…	…	…	…	…	…
…	…	0.54	…	…	0.30	…	…	…	…	…	…
…	…	0.27	…	…	10.30	…	…	…	…	…	…
0.22	0.19	0.21	…	…	7.86	…	…	…	…	…	…
3.20	1.15	2.11	…	…	2.57	…	…	…	…	…	…

*Sulphur.

FODDERS AND FEEDS.

I.

CONCENTRATED FEEDING STUFFS.

The Feeding Stuffs Law.

The Legislature of the State of New Jersey, on March 15th, 1900, passed a law regulating the sale of feeding stuffs in the State in much the same manner as the sale of fertilizing materials has been regulated for the quarter century past. A copy of the full text of this law will be sent to anyone interested, upon application. Briefly stated, the law requires:

1. That every lot or parcel of certain concentrated feeding stuffs (for domestic animals) sold in this State shall have affixed thereto, in a conspicuous place on the outside, a printed statement of:

The number of net pounds contained.
The name or trade-mark of the material.
The name of the manufacturer or shipper.
The percentage of protein contained and the percentage of fat contained.

If the feeding stuff is sold in bulk, or in packages belonging to the purchaser, this statement shall be furnished by the agent or dealer to the purchaser.

2. A certified copy of this statement shall be filed with the Director of the Experiment Station in the month of November of each year, accompanied, when requested, by a sample of the goods.

3. The feeding stuffs which are required to conform with these provisions of the law include:

Brewers' grains, dried,
Cerealine feeds,
Cocoanut meals,
Corn and oat chop,
Cottonseed meals,
Gluten meals, feeds,
Hominy feeds,
Linseed meals,
Maize feeds,
Malt sprouts,
Meat scrap, ground,
Mixed feeds,
Oat feeds,
Pea meals,
Peanut meals,
Rice meals,
Sugar feeds,
Starch feeds

and all similar materials.

4. The following feeding stuffs are exempted from the requirements of the law:

All kinds of hay and straw.
The whole seeds of wheat, barley, rye, oats, Indian corn, buckwheat and broom corn, and the unmixed meals made from the entire grains of any of these.
The meals made from pure grains ground together.
The brans and middlings of wheat, rye and buckwheat when separate and unmixed with any other substances.

5. Should any of these materials, otherwise exempt, be mixed or adulterated with any substance for the purpose of sale, the package which contains it, or in which it is offered for sale, must have plainly marked or indicated thereon the true composition of the mixture, or the character of the adulteration.

6. The Experiment Station is authorized to have collected samples of every kind of material used in the feeding of domestic animals, to analyse them and to publish the results. Penalties, varying from $25 to $200, are provided for violations of the law.

The Sampling and Analysis.

Early in the fall of 1901 the Experiment Station made ready to carry out the second annual inspection of feeding stuffs under the law. Mr. William P. Allen had been permanently added to the Station's staff, and to him solely was assigned the duty of collecting the samples throughout the entire State. Eighteen counties of the State were thoroughly inspected, particular pains being taken with those counties in which the inspection of the previous year had, through lack of time, been superficial. Seven hundred and seventy-eight samples, or 249 more than the year before, were drawn and sent to the Experiment Station.

These were carefully numbered and verified as received, and 558 were analysed, with the results as tabulated upon succeeding pages. The work this year, therefore, includes 89 more samples than the year before, from which it is believed that the inspection has been as thorough and exhaustive as could be desired, even though 220 were dropped from analysis. A score or more of the latter were discarded because the samples had deteriorated and, therefore, did not correctly represent the original goods; the balance were omitted, because they were samples of already more than duplicated goods.

The analyses of the samples selected were made by the staff of the Station's Chemical Department in accordance with the methods of the Association of Official Agricultural Chemists, as required by law. They include the determination of protein and fat (ether extract), and in some cases of fiber or other constituents. Great care has been taken to secure accuracy, and analyses have, in numerous instances, been triplicated when the results have not been in accord with guarantee or with normal composition. When the circumstances in the case seemed to warrant, a microscopical examination, also, was made.

The Classification of Feeds.

The purpose of the law, by authority of which this work is done, is twofold—first, it is to the effect that certain feeds shall be guaranteed, and guaranteed correctly; second, it is to guard the rest of the feeding stuffs from adulteration. The work of the Station, therefore, consists in verifying the accuracy of the guarantees and in examining the various feeding stuffs for contamination or adulteration. The feeds divide themselves naturally, therefore, into two great groups in accordance with their character in this respect. Of the 778 samples received, 426 belong to the group of which guarantees are required, and 352 belong to the group of which they are not.

The feeds of the guaranteed class are further classified as follows: the oil cake meals, which include the pure residues from the pressing out of oil; the corn products, which include the straight by-products from the manipulation of the maize kernel; the brewery and distillery products, which explain themselves; the feed mixtures, which include all cases of ground material compounded to form feeds; the feed substitutes, which consist of certain materials, not properly feeds, which are offered for this purpose; and, finally, a few calf meals, ground meats and poultry foods.

The feeds of which guarantees are not required are grouped as follows: the wheat materials (bran, middlings, feeding flour and feed); buckwheat, rye and barley products; corn meal; cob meal; corn and oats ground together; feeds made from other whole grains ground together; flaxseed meal and three materials of a miscellaneous character.

Guarantees and Actual Composition.

Of the 426 samples received, all of which should be accompanied by a guarantee, 166 were found to be otherwise: in the case of 138 of these, however, the guarantees were filed at the Experiment Station by the manufacturer, and will be published in the tables of analyses for the information of all concerned. Nevertheless, it must not be considered that the filing of this information with us is a substitute for a guarantee which is missing in the sale of the goods. We have good reason to believe that there are numerous cases in which we have been furnished with guarantees and other information that has been withheld from the purchaser. In most cases the manufacturer, however, is probably not at fault, as often the dealers are careless with the tags, especially when they transfer to barrels, boxes or bins.

Another point in the matter of guarantees is that they should be reasonably accurate, and honest attempts to give the composition of the goods as found. When a manufacturer, or other party, responsible for malt sprouts, with 25.22 per cent. of protein; hominy meal, with 11.01 per cent. of protein; oat feed, with 9.79 per cent. of protein, and adulterating material,* with 2.69 per cent. of protein, guarantees each and every one of these to contain but one per cent. of protein, he may think he is complying with the letter of the law; he certainly is not with its spirit. Purchasers of these goods should not imply from the high-grade character of, for instance, the malt sprouts, with a guarantee of one per cent., that all the materials with this low guarantee are high grade; they should not even have faith in the continuation of the genuineness of the malt sprouts itself. On the other hand, all of the feed products of another company suffer in comparison by being guaranteed high on the supposition of an absolutely moisture-free condition—a condition which may be obtained in kiln-drying, but which does not continue very long thereafter. The actual content of these samples, therefore, rarely reaches guarantee.

One hundred and forty-six individual brands are represented by the 426 samples requiring guarantees. Of these brands 125 are accompanied by guarantees in the case of every one of their samples; two brands were guaranteed in some of their samples, but not in others; and nineteen brands were in every case devoid of tag, statement or information of any character. This is 13 per cent. of the total number received, which is a marked improvement over last year, when 32 per cent. of the total number of brands requiring it carried no guarantee.

The brands examined this year are represented by 309 samples. Of these 287 were guaranteed, and in 211 of the latter were the guarantees fulfilled. In other words, 68 per cent. of the samples guaranteed fulfill their promise, which is a further improvement over the year before, when only 60 per cent. accomplished this end.

The samples defective this year are, in addition to the 22 which carried no guarantee, 51 which did not contain the amount of protein promised, 16 similarly deficient in fat and 9 in both protein and fat. There are still, therefore, in a possible 287, 60 cases of a deficiency in protein, the most important constituent of a purchased feed. Last year there were 87 in 289. The dairymen and other feeders of this State may, therefore, be congratulated on the effectiveness of the law providing a feed inspection, even though the same may be considered in the infancy of its operation. If consumers will insist on guarantees, when guarantees are due, an unguaranteed feed will soon be as rare as an unguaranteed fertilizer.

The Purity of the Feeds.

Among the feeds which are guaranteed, the main point to be looked to is whether the guarantee is fulfilled. If this is the case, and the manufacturer delivers the total amount of nutrients guaranteed, it would seem as if enough has been done, and nothing can be said if the sample is contaminatel. This is the case in two samples of linseed meal, of which one contains an oat product and the other some corn; nevertheless they are above guarantee. They are lower, however, than their duplicates which carry the same guarantee. It *is to be deplored that a standard material of this character should* not be strictly pure, as well as up to guarantee, and we can only hope that the contamination has been accidental.

In the case of a sample of malt sprouts, which contains oat hulls, the goods were not accompanied by a guarantee and the responsibility for this double violation of the law should be determined.

Among the 249 samples of materials, in the sale of which the law does not require guarantees, 14 have been found contaminated with foreign material. The adulterations may be summarized as follows:

1 Wheat Bran contains corn.
1 Wheat Bran contains corn, oats, weed-seed and cockle.
1 Wheat Bran contains coffee hulls (cornaline).
1 Brown Middlings contains rice hulls.
1 Wheat Feed contains corncob.
2 Buckwheat Brans contain an excess of hulls.
1 Buckwheat Bran contains peanut.
2 Corn Meals contain cob.
3 Corn and Oats contain oat hulls in excess.
1 Flaxseed Meal contains wheat.

In addition, five corn meals are low grade in protein; they show no evidence of adulterants, but are probably bolted meal, originally intended for human consumption.

While all these adulterations merit the severest condemnation, it remains a matter of congratulation that in a season when feeds have been high and the temptation has been great, over 94 per cent. of the samples of standard feeds, of which no guarantees are required, have been uncontaminated.

Low-Grade Feeds (Feed Substitutes).

On account of the shortage in the corn crop, and the consequent rise in price of all feeding stuffs, many materials which ordinarily are considered as worthless offal of milling, or of other manufacturing processes, have been attracted to market in order to participate in the high prices now ruling. As instances, may be mentioned fine-ground oat hulls, rice hulls, coffee hulls and cornstalks, which have been found not only as adulterants and forming parts of mixtures, but also clear, and themselves masquerading as feeds.

Feeders are apt to be misled in the purchase of such materials, because the price asked, judged from the prices of standard feed in ordinary years, would indicate worth which they do not possess, and because the absence of an advance in the prices of dairy products in full sympathy with that in the prices of feeds renders attractive any supposed economy in the purpose of the latter.

Economical purchase, however, does not imply the purchase of the lowest-priced feeds; what is secured for the money is the important consideration. Many of the waste products alluded to are not absolutely worthless, but it is important that purchasers should know what they are and what relation they bear to the standard feeds. In most cases they are not feeds at all, but fine-ground materials that are essentially inferior to the common roughage of the

farm. Purchasers should not be deceived in such a case by false claims or a fancy name, suggesting good quality or good origin. The Station, believing the matter of sufficient importance, issued a bulletin of warning under date of February 14th, 1902, and the advice then given is here repeated:

Purchase nothing unless with the material is furnished the definite guarantee which the law requires shall accompany all kinds of feed, except a few products like bran, middlings, corn meal, &c. These are excepted because the law characterizes any tampering with them as adulteration, to be dealt with accordingly. All other by-products and mixtures must be accompanied by a statement of composition.

We regret to say that this has not always been the case. Customers have been furnished with a name and a price. Subsequent demand by the Station has elicited a guarantee from the manufacturer or jobber, which, if furnished with the material, would certainly not have promoted its sale.

Average Composition and Selling Prices.

The Experiment Station this year omits from the tables the detailed publication of the dealers' prices of the several feeds. These were in every case recorded, however, and the average prices of the different kinds of feeding stuffs and of the different proprietary brands have been calculated.

The following table shows the average selling prices of the several feeds for animals, with their average composition, arranged in the order of their protein content:

	Protein. %	Fat. %	Selling Price.
Cottonseed Meal	44.40	10.71	$30 24
Linseed Meal	35.49	8.90	36 26
Chicago Gluten Meal	35.07	5.64	29 50
Crackerjack Dairy Feed	30.80	11.96	27 50
Buckwheat Middlings	27.89	7.45	22 00
Dried Brewers' Grains	26.57	7.26	22 91
Gluten Feeds	25.88	3.75	27 30
Malt Sprouts	25.56	3.01	21 00
Cocoanut Meal	23.76	14.02	20 00
Grano Gluten Feed	23.05	10.37	21 50
Buckwheat Bran	22 62	6.66	22 00
Feeding Flour	20.71	5.64	28 33
Sucrene Dairy Feed	19.78	8.66	26 00
Germ Oil Meal	19.60	8.67	26 50
Dried Distillers' Grains	19.45	8.44	21 67

	Protein. %	Fat. %	Selling Price.
H. O. Dairy Feed	19.16	4.47	29 00
Brown Middlings	18.61	6.43	27 33
Mixed Wheat Feed	17.52	5.18	25 76
Spring Wheat Bran	16.97	5.27	25 54
Rye Middlings	16.81	3.64	25 00
Barley Feed	16.76	4.48	....
Buckwheat Feed	16.51	4.60	20 00
Winter Wheat Bran	15.96	4.63	25 70
Quaker Dairy Feed	15.85	4.21	24 56
Wheat Middlings	15.21	3.85	28 14
H. O Horse Feed	14.64	5.56	29 99
Rye Bran	14.12	3.53	23 00
Schumacher Corn, Oats and Barley	13.67	6.42	30 75
Marsden Feed, No. 1	13.65	5.05	20 00
Local Feed Mixtures	11.42	4.94	26 97
Hominy Meal (Feed)	11.36	8.18	27 77
Cottonseed Feed	10.79	3.56	15 00
Corn Bran (Sugar Feed)	10.73	5.81	19 66
Friend's Feed	10.70	4.07	23 25
Yellow Meal	10.64	4.10	30 00
Cerealine Feed	10 43	7.88	27 69
Horse Feeds (Mixed Grains)	10.43	3.41	28 33
Provender (Corn and Oats	10.05	3.92	29 69
Fish's Oat Feed	9.79	3.85	20 75
Maizeline Feed	9.62	7.91	26 75
Victor Corn and Oat Feed	9.56	4.70	25 61
Rye Feed	9.54	2.09	25 25
Corn Meal	9.09	4.32	28 95
Boss Corn and Oat Feed	9.04	4.43	23 50
Monarch Oat Chop	8.89	3.59	26 00
De Fi Corn and Oat Feed	8.63	3.08	25 00
Taylor Brothers' Oat Feed	8.49	3.78	16 75
Vim Oat Feed	7.71	2.94	20 58
Cob Meal	7.63	2.71	23 80
Royal Oat Feed	7.35	2.62	19 50
Bang's Oat Feed	4.85	1.99	18 88
Hildebrandt's Oat Feed	4.84	1.72	20 00
Marsden Feed, No. 2	4.03	1.28	....
Independence Oat Feed	3.30	1.06	21 50
Rice "Meal"	2.94	1.20	17 50
Cornaline	2.69	0.58	20 00
Sitley's Oat Feed	2.54	0.78	20 00

The Selection of Feeds.

An inspection of the foregoing table shows the well-known fact that the price of a feed is no index to its value from the standpoint either of nutrients contained or of suitability to the usual farm purposes. The distinguishing feature of the various feeds, the content of protein, has therefore been made the basis of classification. Feeds of high protein content are purchased for the express purpose of improving the ration by the addition of protein, the hay, corn fodder, ensilage, &c., which forms the balance of the ration being deficient in this ingredient.

Materials which are low in protein are therefore not suitable objects of purchase for this purpose, since they themselves are, at best, balanced rations, or else require the addition of protein feeds the same as the farm products do. As farmers usually have an abundance of low-grade farm products, these feeds appeal only to the city feeders of horses and stall-fed cattle, where all the feeding material must be purchased.

It remains for the purchaser to select, bearing this distinction in mind. The list from which his selection may be made is composed of a half dozen pretty well defined groups. They range in protein content from more than 40 per cent. to less than 5 per cent., and include some of the most valuable feeds, as well as some of the veriest trash. The groups may be outlined as follows:

1. Cottonseed, linseed and Chicago gluten meals and crackerjack dairy feed (a low-grade linseed meal), furnishing from 30 to 45 per cent. of protein, and costing approximately from $27 to $36 per ton.

2. The by-products of the manufacture of starch, glucose, spirits and beer, cocoanut meal, feeding flour (wheat) and buckwheat bran and middlings, furnishing from 19 to 28 per cent. of protein, and costing approximately from $20 to $28 per ton.

3. The wheat and rye brans, middlings and feed, &c., and the H. O. Dairy and Quaker Dairy feeds, furnishing from 15 to 19 per cent. of protein, and costing from $20 to $29 per ton.

4. Corn bran (sugar feed), cerealine feed, hominy feed and the artificial feed mixtures, furnishing from 10 to 15 per cent. of protein, and costing from $15 to $30 per ton.

5. Low-grade feeds, largely oat chop and oat hulls, furnishing from 7 to 10 per cent. of protein, at from $16 to $29 per ton, and con-

sisting, in many cases, of fiber (hulls, &c.), to the extent of one-fourth their weight.

6. Feed substitutes, furnishing less than 5 per cent. of protein, at about $20 per ton, and consisting of from one-fourth to one-half fiber.

Summary.

1. Of the 146 distinct brands of feed received, and which should be guaranteed, 19 were devoid of tag, statement or guarantee.

2. Consumers are advised to purchase nothing unless with the material is furnished the definite guarantee which the law requires shall accompany all kinds of feed, except a few products like bran, middlings, corn meal, &c.

3. Of the 287 samples which were guaranteed, and of which an examination was made, 76 failed in their promises, 60 of these being deficient in protein.

4. Among the 249 samples of feeds not required to be guaranteed, 14 were found to be contaminated or adulterated with foreign matter, principally offal of milling.

5. There are on the feed market a considerable number of very inferior feeds, which consist of oat hulls, rice hulls, coffee hulls, etc., which cannot form a profitable purchase at any price.

6. In buying feeds to supplement his home-grown supply, the dairyman's aim should be to secure digestible and palatable protein on the most reasonable terms and in the most economical forms. Fully half of the different and distinct kinds of feeds in the tables do not meet his requirements in this respect. Therefore, study the composition of feeds as shown in their guarantees and in the tables of analyses.

OIL CAKE MEALS.

Cottonseed Meal.

PRIME BRAND.

Station number.	Manufacturer or Jobber and Dealer.	Place of Sampling.	Protein. Found.	Protein. Guaranteed	Fat. Found	Fat. Guaranteed.
	American Cotton Oil Co, New York City.		%	%	%	%
2286	J. C. Smith & Wallace Co.	Newark	45.51	43.00	9.43	9.00
2419	D. F. Hendrickson	Woodbury	44.08	43.00	9.63	9.00
2457	Fithian & Pennell	Bridgeton	44.28	43.00	9.70	9.00
2506	Mixner & Mickel	Bridgeton	43.54	43.00	11 24	9.00
2560	Trenton Mills and Elevator Co	Trenton	46.46	43.09	11.05	9.00
	Average		44.76	43.00	10.21	9.00

CANARY BRAND.

	R. W. Biggs & Co., Memphis, Tenn.					
2287	Wilkinson, Gaddis & Co	Newark	47.04	43.00	9.93	9.00
2348	Vroom & Butler	Somerville	42.51	43.00	16.65	9.00
2535	J. E. Stevenson & Co.	Trenton	43.42	43.00	9.68	9.00
2566	Stults Bros.	Trenton	45.38	43.00	8.86	9.00
2608	C. H. Snyder & Son	Freehold	41.22	43.00	16.64	9.00
	Average		43.91	43.00	12.34	9.00

OWL BRAND.

	F. W. Brode & Co., Memphis, Tenn.					
2426	Peterson & Smith	Woodstown	44.22	43.00	11.62	9.00
2658	C. C. Dempsey	Gloucester	45.90	43.00	10.49	9.00
2716	W D. Rogers & Co.	Moorsetown	44.19	43.00	9.38	9.00
	Average		44.77	43.00	10.50	9.00

GREEN DIAMOND BRAND.

	Chapin & Co., Philadelphia, Pa.					
2292	A. Cyphers	Newark	47.38	43.00	10.52	9.00
2463	W. O. Garrison	Bridgeton	44.89	43.00	8.32	9.00
2215	W. H. Ingersoll	Hamburg	44.08	43.00	8.52	9.00
	Average		45.42	43.00	9.12	9.00

OIL CAKE MEALS.

Cottonseed Meal—Continued.

STAR BRAND.

Station number.	Manufacturer or Jobber and Dealer.	Place of Sampling.	Protein Found.	Protein Guaranteed.	Fat. Found.	Fat. Guaranteed.
	Cole, Cleaveland & Curley, New York City.		%	%	%	%
2168	C. A. Wilson Co.	Deckertown	46.97	48.00	10.50	9.00
2182	Simmons & Martin	Deckertown	46.17	48.00	10.06	9.00
	Average		46.57	48.00	10.28	9.00

COFCO BRAND.

Station number.	Manufacturer or Jobber and Dealer.	Place of Sampling.	Protein Found.	Protein Guaranteed.	Fat. Found.	Fat. Guaranteed.
	Cotton Oil and Fiber Co., Norfolk, Va.					
2033	Sharpless & Bro.	Camden	41.11	48.00	11.68	9.00
2035	Taylor Bros	Camden	44.88	48.00	9.58	9.00
2462	J. K. Waddington	Salem	41.59	48.00	11.54	9.00
2493	C. G. Lippincott	Salem	41.69	48.00	11.98	9.00
2508	Sheard & Brooks	Vineland	41.81	48.00	11.05	9.00
2510	Clure & Niggin	Vineland	41.66	48.00	12.37	9.00
2586	S. L. Pancoast	Mullica Hill	40.88	48.00	10.50	9.00
2722	Hopkins & Lippincott	Moorestown	42.18	48.00	11.21	9.00
	Average		41.96	48.00	11.23	9.00

LILY BRAND.

Station number.	Manufacturer or Jobber and Dealer.	Place of Sampling.	Protein Found.	Protein Guaranteed.	Fat. Found.	Fat. Guaranteed.
	Hunter Bros., St. Louis, Mo.					
2274	Jaqui & Co.	Morristown	45.13	48.00	10.85	9.00

SITLEY & SON'S BRAND.

Station number.	Manufacturer or Jobber and Dealer.	Place of Sampling.	Protein Found.	Protein Guaranteed.	Fat. Found.	Fat. Guaranteed.
	Sitley & Son, Camden, N. J.					
2059	Sitley & Son	Camden	42.69	48.00	11.58	9.00

TAR HEEL BRAND.

Station number.	Manufacturer or Jobber and Dealer.	Place of Sampling.	Protein Found.	Protein Guaranteed.	Fat. Found.	Fat. Guaranteed.
	D. R. Worman, Philadelphia, Pa.					
2454	Davis, Colson & Co	Woodstown	46.48	48.00	9.94	9.00
2495	R. W. Smith	Elmer	43.48	48.00	11.62	9.00
2496	Hires & Co.	Quinton	43.18	48.00	9.47	9.00
	Average		44.38	48.00	10.34	9.00

OIL CAKE MEALS.

Linseed Meal.

Station number.	Manufacturer or Jobber and Dealer.	Place of Sampling.	Protein. Found.	Protein. Guaranteed.	Fat. Found.	Fat. Guaranteed.
	American Linseed Co., Chicago, Ill.		%	%	%	%
2002	J. Halpin	Elizabeth	38.19	32.00	8.89	5.00
2079	J. E. Lovett & Son	Hackensack	*33.17	32.00	6.95	5.00
2025	C. E. Pountney	Elizabeth	38.69	36.00	8.06	6.00
2286	Wilkinson, Gaddis & Co.	Newark	38.19	36.00	8.17	6.00
2107	J. English	Paterson	37.68	36.00	7.68	6.00
2011	Cranford Flour and Feed Store	Cranford	38.02	32.00	8.70	5.00
2448	D. F. Hendrickson	Woodbury	37.55	36.00	6.20	6.00
2456	Fithian & Pennell	Bridgeton	30.83	32.00	11.72	5.00
2030	Taylor Bros.	Camden	33.51	32.00	7.36	5.00
2080	Vile & Son	Jersey City	35.85	32.00	7.87	5.00
2113	J. A. Lydecker	Paterson	37.31	32.00	7.54	5.00
2347	Vroom & Butler	Somerville	35.59	32.00	7.24	6.00
2594	H. Banker	New Brunswick	34.46	32.00	6.75	5.00
2602	C. H. Snyder & Son	Freehold	35.84	36.00	6.67	6.00
2078	P. O'Blenis	Paterson	34.48	32.00	7.77	5.00
2081	Carscallan & Cassidy	Jersey City	36.53	36.00	7.64	6.00
2082	Meyer & DeVogel	Paterson	36.29	36.00	6.79	6.00
2596	C. W. Russell	New Brunswick	37.49	36.00	7.08	6.00
2627	F. D. Wikoff	Red Bank	36.77	36.00	8.18	6.00
2650	J. Guire & Bro.	West End	36.05	36.00	7.48	6.00
2712	W. D. Rogers & Co.	Moorestown	38.10	32.00	9.26	5.00
	Average		38.19	†36.00	7.80	‡6.00
	The Grove Linseed Oil Co., Philadelphia, Pa.					
2588	S. L. Pancoast	Mullica Hill	31.51	34.00	11.38	5.00
2694	C. C. Dempsey	Gloucester	31.97	34.00	10.99	5.00
	Average		31.74	34.00	11.19	5.00
	Hauenstein & Co., Buffalo, N. Y.					
2164	Hart & Iliff	Newton	37.83	37.82	7.72	7.54
	Hunter Bros., St. Louis, Mo.,					
2482	W. O. Garrison	Bridgeton	38.11	34.00	9.91	6.50
2517	Klure & Niggin	Vineland	37.94	34.00	8.33	6.50
	Average		38.03	34.00	9.12	6.50
	Metzger Seed and Oil Co., Toledo, Ohio.					
2098	Miller & Bertholf	Jersey City	37.11	32.00	7.22	5.00
2099	A. Hannibal	Hoboken	37.89	32.00	6.98	5.00
	Average		37.50	32.00	7.10	5.00

* Contains corn.

† Guarantee filed by manufacturer.

OIL CAKE MEALS—CORN PRODUCTS.

Linseed Meal—Continued.

Station number.	Manufacturer or Jobber and Dealer.	Place of Sampling.	Protein. Found.	Protein. Guaranteed.	Fat. Found.	Fat. Guaranteed.
	Midland Linseed Oil Co., Minneapolis, Minn.		%	%	%	%
2118	J. & H. Steinberg	Passaic	33.28	32.50	9.34	5.50
2297	J. C. Smith & Wallace Co	Newark	34.61	32.50	10.31	5.50
2330	H. Nischwitz & Co.	Plainfield	35.84	32.50	10.70	5.50
2333	Mundy Bros.	Bound Brook	34.84	32.50	10.08	5.50
2119	John Post	Passaic	32.78	32.50	7.95	5.50
	Average		34.16	32.50	9.68	5.50
	T. J. Preston & Co., Newark, N. J.					
2121	R. J. O'Brien	Passaic	*32.26	32.00	7.11	5.00
2299	A. Cyphers	Newark	35.35	32.00	7.34	5.00
2100	Holley & Smith	Hackensack	35.07	32.00	7.40	5.00
	Average		34.23	32.00	7.28	5.00
	Sitley & Son, Camden, N. J.					
2064	Sitley & Son	Camden	33.40	32.00	7.45	5.00
	Source Unknown.					
2611	J. W. Keough	Keyport	36.27	....	12.30	....

COCOANUT CAKE.

2774	**Oil Seeds Pressing Co., New York City.** J. L. Hope	Madison	28.76	24.30	14.02	8.84

GERM OIL MEAL.

	Cerealine Mfg. Co., Indianapolis, Ind.					
2718	W. D. Rodgers & Co.	Moorestown	17.10	15.00	8.68	8.00
	Glucose Sugar Ref. Co., Chicago, Ill.					
2682	G. W. Norton	Hightstown	22.09	24.50	8.81	9.50

CHICAGO GLUTEN MEAL.

	Glucose Sugar Ref. Co., Chicago, Ill.					
2188	R. V. Northrup	Augusta	35.47	38.00	5.43	3.02
2729	W. D. Rogers & Co.	Moorestown	34.66	37.72	5.85	2.05
	Average		35.07	†38.00	5.64	†3.50

* Contains oats.

† Guarantee filed by manufacturer as percentages of the absolutely dry substance.

CORN PRODUCTS.

BUFFALO GLUTEN FEED.

Station number.	Manufacturer or Jobber and Dealer.	Place of Sampling.	Protein. Found.	Protein. Guaranteed.	Fat. Found.	Fat. Guaranteed.
	Glucose Sugar Ref. Co., Chicago, Ill.		%	%	%	%
2114	J. A. Lydecker	Paterson	26.01	28.50	3.33	2.50
2175	C. A. Wilson Co.	Deckertown	23.58	27.50	4.85	3.50
2186	Simmons and Martin	Deckertown	27.98	27.50	4.56	3.50
2192	R. V. Northrup	Augusta	26.48	27.00	3.07	3.00
2476	Fithian & Pennell	Bridgeton	27.21	27.50	3.27	3.00
2477	Ewen Milling Co	Alloway	25.81	27.50	3.27	3.50
2037	O. H. Kirby	Medford	26.98	27.00	3.06	3.00
2039	Taylor Bros	Camden	27.84	26.90	4.21	3.50
2143	A. N. Roe	Branchville	27.84	28.50	3.37	3.30
2379	A. A. Cortelyou	Neshanic	24.89	27.50	3.20	3.50
2380	F. F. Lear	Lambertville	26.86	27.50	3.96	3.50
2481	Davis, Colson & Co	Woodstown	27.96	27.50	3.61	3.50
2515	A. G. Johnson	Bridgeton	26.73	27.50	2.94	3.50
2537	S. L. Pancoast	Mullica Hill	25.26	27.00	3.06	3.00
2570	Stults Bros	Trenton	27.34	27.50	3.16	3.50
2405	Jos. Smith & Co	Stockton	27.89	27.50	3.42	3.50
2695	C. C. Dempsey	Gloucester	27.55	27.50	3.53	3.50
2728	W. D. Rogers & Co	Moorestown	25.83	27.83	3.46	2.96
2764	T. S. Page & Co	Columbus	26.98	27.50	4.60	3.50
	Average		26.61	*27.50	3.60	*3.50

DAVENPORT GLUTEN FEED.

Station number.	Manufacturer or Jobber and Dealer.	Place of Sampling.	Protein. Found.	Protein. Guaranteed.	Fat. Found.	Fat. Guaranteed.
	Glucose Sugar Ref. Co., Chicago, Ill.					
2101	P. O'Blenis	Paterson	24.16	28.50	3.94	2.50
2209	G. O. Young	Tranquility	25.21	24.18	4.34	3.75
2631	G. W. Norton	Hightstown	25.88	27.50	6.13	3.50
	Average		25.08	*27.50	4.80	*3.50

ROCKFORD DIAMOND GLUTEN FEED.

Station number.	Manufacturer or Jobber and Dealer.	Place of Sampling.	Protein. Found.	Protein. Guaranteed.	Fat. Found.	Fat. Guaranteed.
	Glucose Sugar Ref. Co., Chicago, Ill.					
2088	Long Dock Mills and Elevator Co	Jersey City	26.54	26.20	4.28	2.70
2216	W. H. Ingersoll	Hamburg	25.98	27.50	3.79	3.50
	Average		26.24	*27.50	4.04	*3.50

GRANO GLUTEN FEED.

Station number.	Manufacturer or Jobber and Dealer.	Place of Sampling.	Protein. Found.	Protein. Guaranteed.	Fat. Found.	Fat. Guaranteed.
	Hottelet & Co., Milwaukee, Wis.					
2481	R. W. Smith	Elmer	23.05	25.00	10.87	7.00

*Guranteed filed by manufacturer as percentages of the absolutely dry substance.

CORN PRODUCTS.

PEKIN GLUTEN FEED.

Station number.	Manufacturer or Jobber and Dealer.	Place of Sampling.	Protein. Found.	Protein. Guaranteed.	Fat. Found.	Fat. Guaranteed.
	Illinois Sugar Ref. Co., Pekin, Ill.		%	%	%	%
2552	C. A. Reid	Pennington	26.12	27.70	3.10	3.50

NATIONAL GLUTEN FEED.

Station number.	Manufacturer or Jobber and Dealer.	Place of Sampling.	Protein. Found.	Protein. Guaranteed.	Fat. Found.	Fat. Guaranteed.
	National Starch Mfg. Co., New York City.					
2279	Jaqui & Co	Morristown	25.83	27.10	3.18	2.90
2371	Thos. Eggert & Co	Perth Amboy	24.95	31.70	2.80	4.80
2573	Trenton Mills and Elevator Co	Trenton	32.62	39.00	2.68	3.50
2574	Trenton Mills and Elevator Co	Trenton	22.56	27.10	4.47	3.20
2592	H. Banker	New Brunswick	22.87	31.70	2.78	4.30
2432	Davis, Colson & Co	Woodstown	20.00	28.00	3.73	3.00
2766	T. S. Page & Co	Columbus	21.80	22.90	2.76	2.80
	Average		24.30	28.98	3.19	3.36

WAUKEGAN GLUTEN FEED.

Station number.	Manufacturer or Jobber and Dealer.	Place of Sampling.	Protein. Found.	Protein. Guaranteed.	Fat. Found.	Fat. Guaranteed.
	U. S. Sugar Refining Co., Waukegan, Ill.					
2304	A. Cyphers	Newark	26.80	27.38	4.41	3.89
2124	Campbell, Morrell & Co	Passaic	26.97	27.38	3.09	3.89
2771	Estate J. W. Biddle	Columbus	*20.38	27.38	*3.81	3.89
	Average		26.94	27.38	3.75	3.89

MISCELLANEOUS GLUTEN FEEDS.

Station number.	Manufacturer or Jobber and Dealer.	Place of Sampling.	Protein. Found.	Protein. Guaranteed.	Fat. Found.	Fat. Guaranteed.
2097	Meyer & DeVogel	Paterson	26.57	....	4.45	....
2370	*J. J. Nash*	*Perth Amboy*	25.48	....	3.83	....
2054	Sharpless & Bro	Camden	29.54	....	3.03	....
2521	Sharpless & Bro	Camden	27.15	....	3.06	....
2038	Taylor Bros	Camden	28.29	27.50	4.25	3.50
2497	J. K. Waddington	Salem	24.50	....	3.18	....

* Omitted from the average.

CORN PRODUCTS.

HOMINY MEAL.

Station number.	Manufacturer or Jobber and Dealer.	Place of Sampling.	Protein. Found.	Protein. Guaranteed.	Fat. Found.	Fat. Guaranteed.
	American Cereal Co., Chicago, Ill.		%	%	%	%
2154	S. Hill	Newton	10.86	10.74	7.18	6.20
	Cambridge Cereal and Packing Co., Cambridge, Ind.					
2568	J. H. Ashton	Trenton	11.57	9.50	7.98	7.50
	Decatur Cereal Mill Co., Decatur, Ill.					
2160	Hopkins & Williams	Newton	11.50	11.80	8.00	9.18
	Fish & Co., New York City.					
2085	P. O'Blenis	Paterson	11.01	1.00	7.97	1.00
	Howell & Webster, Middletown, N. Y.					
2110	J. A. Lydecker	Paterson	10.96	....	7.83	....
	The Hudnut Co., Terre Haute, Ind.					
2288	A. Cyphers	Newark	10.76	12.85	8.00	8.52
	Hunter Bros., St. Louis, Mo.					
2600	C. W. Russell	New Brunswick	11.94	11.02	7.96	7.70
	Indianapolis Hominy Mills, Indianapolis, Ind.					
2210	G. O Young	Tranquility	11.01	11.62	8.14	8.48
	Miami Maize Co., Toledo, O.					
2141	A. N. Roe	Branchville	11.01	10.98	7.40	7.05
	Miner-Hilliard Milling Co., Wilkesbarre, Pa.					
2296	J. C. Smith & Wallace Co	Newark	12.23	10.87	9.05	8.46
	Shellabarger Mill and Elevator Co., Decatur, Ill.					
2105	J. English	Paterson	11.18	11.56	9.90	8.52
2258	J. Gardner	Dover	11.62	11.56	9.89	8.52
	Sitley & Son, Camden, N. J.					
2748	Colkitt & Thomson	Mount Holly	11.36	....	8.01	....
	Suffern, Hunt & Co., Decatur, Ill.					
2151	McDonalds & Fox	Branchville	12.84	11.02	9.24	7.70
2378	J. Van Buren	Rahway	11.28	11.02	9.14	7.70
	Average of all brands	....	11.36	11.19	8.18	7.98

CORN PRODUCTS.

CEREALINE FEED.

Station number.	Manufacturer or Jobber and Dealer.	Place of Sampling.	Protein. Found.	Protein. Guaranteed.	Fat. Found.	Fat. Guaranteed	Fiber.
	Cerealine Mfg. Co., Indianapolis, Ind.		%	%	%	%	%
2063	Sitley & Son	Camden	10.16	7.88	7.18	5.99	....
2719	W. D. Rogers & Co	Moorestown	9.87	7.88	6.97	5.45	....
2720	J. S. Collins & Son	Moorestown	10.21	7.88	6.49	5.99	....
2761	T. S. Page & Co	Columbus	8.95	7.88	7.21	5.99	....
2762	Estate J. W. Biddle	Columbus	10.21	7.88	6.81	5.00	....
2179	Simmons & Martin	Deckertown	11.28	9.00	8.18	5.82	....
2223	R. Harden	Hamburg	10.72	10.82	8.06	8.62	....
2763	Estate J. W. Biddle	Columbus	12.05	10.82	10.15	8.08	....
	Average		10.43	8.61	7.88	6.86	....

MAIZELINE FEED.

Station number.	Manufacturer or Jobber and Dealer.	Place of Sampling.	Protein. Found.	Protein. Guaranteed.	Fat. Found.	Fat. Guaranteed	Fiber.
	The Hudnut Co., Terre Haute, Ind.						
2040	Sitley & Son	Camden	9.42	10.42	9.22	9.03	....
2480	F. D. Duffield	Elmer	9.81	10.00	6.59	8.56	....
	Average		9.62	10.21	7.91	8.80	....

CORN BRAN, OR SUGAR FEED.

Station number.	Manufacturer or Jobber and Dealer.	Place of Sampling.	Protein. Found.	Protein. Guaranteed.	Fat. Found.	Fat. Guaranteed	Fiber.
	Glucose Sugar Ref. Co., Chicago, Ill.						
2159	Hopkins & Williams	Newton	13.20	14.00	4.14	3.50	9.58
2045	C. H. Kirby	Medford	12.89	13.68	4.40	3.66	12.29
2478	Ewen Milling Co	Alloway	11.16	14.00	4.25	3.50	11.83
2281	Reeve Harden	Hamburg	12.97	14.00	3.74	3.50	10.71
2479	J. K. Waddington	Salem	9.69	14.00	2.94	3.50	10.13
2709	C. C. Dempsey	Gloucester	12.45	14.00	3.82	3.50	10.98
	Average		11.96	*14.00	3.88	*3.50	10.91
	Howell & Webster, Middletown, N. Y.						
2198	R. V. Northrup	Augusta	10.18	9.00	5.77	1.50	11.57
	Liberty Mills, Nashville, Tenn.						
2459	R. W. Smith	Elmer	10.54	9.90	9.52	7.48	9.01
	John Rankin & Co., Chicago, Ill.						
2051	Taylor Bros	Camden	11.03	9.00	3.89	3.00	12.08
2067	B. M. Beideman	Merchantville	10.18	9.00	3.57	3.00	12.80
2188	A. N. Roe	Branchville	9.39	9.44	4.76	1.60	13.64
	Average		10.20	9.15	4.07	2.53	12.84

*Guarantee filed by manufacturer as percentages of the absolutely dry substance.

BREWERY AND DISTILLERY PRODUCTS.

MALT SPROUTS.

Station number.	Manufacturer or Jobber and Dealer.	Place of Sampling.	Protein. Found	Protein. Guaranteed.	Fat. Found.	Fat. Guaranteed.
	Chapin & Co., Philadelphia, Pa.		%	%	%	%
2157	Hopkins & Williams	Newton	26.66	24.00	3.46	3.00
2268	Jaqui & Co	Morristown	*21.21	....	2.49	....
	Average		23.44	24.00	2.98	3.00
	H. C. Edwards, Chicago, Ill.					
2036	Taylor Bros	Camden	25.94	23.00	2.93	2.95
	Fish & Co., New York City.					
2163	Hart & Iliff	Newton	24.14	1.00	2.57	1.00
2087	P. O'Blenis	Paterson	26.30	1.00	3.32	1.00
	Average		25.22	†1.00	2.95	†1.00
	F. W. Goeke & Co., St. Louis, Mo.					
2558	C. A. Reed	Pennington	24.40	23.48	3.48	1.68
2174	C. A. Wilson Co	Deckertown	26.36	23.48	1.67	1.68
	Average		25.38	23.48	2.58	1.68
	P. C. Kamm & Co., Milwaukee, Wis.					
2115	J. A. Lydecker	Paterson	25.56	26.25	3.48	1.01
2178	Simmons & Martin	Deckertown	25.81	26.25	4.08	1.01
	Average		25.68	26.25	3.76	1.01
	A. Meurer & Co., Milwaukee, Wis.					
2189	R. V. Northrup	Augusta	29.23	24.00	4.38	3 93
2246	R. Harden	Hamburg	23.39	26.25	2.28	1.01
	Average		26.31	25.13	3.33	2.47
	E. P. Mueller, Milwaukee, Wis.					
2212	G. O. Young	Tranquility	26.96	24.39	2.06	2.88
2529	J. E Stevenson Co.	Trenton	27.23	26.25	4.25	1.01
2049	C. H. Kirby	Medford	25.81	26.75	2.39	1.01
2561	Stults Bros	Trenton	25.81	26.25	3.35	1.01
	Average		26.45	25.91	3.01	1.35
	M. G. Rankin & Co., Milwaukee, Wis.					
2578	Trenton Mills and Elevator Co	Trenton	22.56	26.25	2.15	1.01
	Sitley & Son, Camden, N. J.					
2065	J. R. Wilkinson	Vincentown	26.79	25.19	3.31	0.67
2490	C. G. Lippincott	Salem	27.75	25.19	2.89	0.67
	Average		27.27	25.19	3.10	0.67
	Source Unknown.					
2106	J. English	Paterson	26.86	....	2.88	....
2096	Meyer & DeVogel	Paterson	26.57	....	3.48	....
	Average of all brands		25.66	24.94	3.01	1.77

* Contains oat hulls.

BREWERY AND DISTILLERY PRODUCTS.

DRIED BREWERS' GRAINS.

Station number.	Manufacturer or Jobber and Dealer.	Place of Sampling.	Protein.		Fat.	
			Found.	Guaranteed.	Found.	Guaranteed.
	Atlantic Export Co., New York City.		%	%	%	%
2756	T. S. Page & Co	Columbus	20.20	28.22	6.71	7.10
2751	Colkitt & Thomson	Mount Holly	24.27	28.22	7.30	7.10
	Average		22.24	28.22	7.01	7.10
	Chapin & Co., Philadelphia, Pa.					
2158	Hopkins & Williams	Newton	28.01	24.00	7.54	8.00
	P. C. Kamm & Co., Milwaukee, Wis.					
2116	J. A. Lydecker.	Paterson	26.78	28.85	7 19	6.18
	J. C. Klauder Estate, Philadelphia, Pa.					
2042	Taylor Bros	Camden	21.94	22.59	7.71	7.90
2048	C. H. Kirby	Medford	22.96	23.24	6.54	7.64
2041	Sharpless & Bro	Camden	23.61	23.24	7.24	7.64
2706	C. C. Dempsey	Gloucester	31.51	23.24	8.27	7.64
2743	Hopkins & Lippincott	Moorestown	27.55	31.68	7.60	6.84
2765	Estate J. W. Biddle	Columbus	29.04	22.06	9.22	6.84
	Average		26.10	*23.24	7.76	*7.84
	A. Meurer & Co., Milwaukee, Wis.					
2162	Hart & Iliff	Newton	28.74	23.00	7.66	6.00
2191	R. V. Northrup	Augusta	27.28	25.00	6.83	3.00
	Average		28.01	24.00	7.25	4.50
	E. P. Mueller, Milwaukee, Wis.					
2211	G. O Young	Tranquility	24.65	25.38	6.50	7.25
2276	Jaqui & Co.	Morristown	28.50	23.85	6.64	6.18
2591	T. Dugan.	New Brunswick	25.94	24.86	7.48	5.69
2140	A. N. Roe	Branchville	30.00	23.85	7.66	6.18
	Average		27.27	*23.85	7.07	*6.18
	Penn Grains and Feed Co., Philadelphia, Pa.					
2396	A. A. Cortelyou	Neshanic	25.51	23.30	6.48	4.97
	Sitley & Son, Camden, N. J.					
2061	Sitley & Son	Camden	31.49	31.63	8.28	6.84
	Source Unknown.					
2583	A. K. Ashby..	Burlington	28.99	......	7.82	......
2725	J. S. Collins & Son	Moorestown	26.86	21.00	7.28	7.00
2186	Simmons & Martin	Deckertown	23.85	......	6.80	......
2072	J. R. Wilkinson	Vincentown	23.78	......	7.18	......
	Average of all brands		26.57	24.79	7.28	6.42

* Guarantee filed by manufacturer.

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BREWERY AND DISTILLERY PRODUCTS.

DRIED DISTILLERS' GRAINS.

Station number.	Manufacturer or Jobber and Dealer.	Place of Sampling.	Protein. Found.	Protein. Guaranteed.	Fat. Found.	Fat. Guaranteed.
	Atlantic Export Co., New York City.		%	%	%	%
2747	W. D. Rogers & Co	Moorestown	20.89	18.80	9.05	6.50
	Bernheim Bros., Louisville, Ky.					
2564	Trenton Mills and Elevator Co	Trenton	19.20	....	9.66	....
	A. Meurer & Co., Milwaukee, Wis.					
2191	R. V. Northrup	Augusta	18.27	20.00	6.60	1.50
	Average of all brands		19.45	19.40	8.44	4.00

FEED MIXTURES.

COTTONSEED FEED.[1]

Station number.	Manufacturer or Jobber and Dealer.	Place of Sampling.	Protein. Found.	Protein. Guaranteed.	Fat. Found.	Fat. Guaranteed.	Fiber.
	Southern Cotton Oil Co., Charlotte, N. C.		%	%	%	%	%
2546	J. E. Stevenson Co	Trenton	10.79	10.00	8.56	8.00	31.42

CRACKERJACK DAIRY FEED.[2]

Station number.	Manufacturer or Jobber and Dealer.	Place of Sampling.	Protein. Found.	Protein. Guaranteed.	Fat. Found.	Fat. Guaranteed.	Fiber.
	Cotton Oil and Fiber Co., Norfolk, Va.						
2084	Taylor Bros	Camden	30.80	30.62	11.96	15.60	7.85

SUCRENE DAIRY FEED.[3]

Station number.	Manufacturer or Jobber and Dealer.	Place of Sampling.	Protein. Found.	Protein. Guaranteed.	Fat. Found.	Fat. Guaranteed.	Fiber.
	American Milling Co., Chicago, Ill.						
2388	Vroom & Butler	Somerville	19.52	16.50	7.86	3.50	....
2424	Davis, Colson & Co	Woodstown	20.03	16.60	9.45	3.50	....
	Average		19.78	16.50	8.66	3.50	....

[1] Cottonseed meal and hulls.
[2] Substantially a low grade linseed meal.
[3] Substantially a brewers' or distillers' grains.

FEED MIXTURES.

SCHUMACHER STOCK FEED (Corn, Oats and Barley).

Station number.	Manufacturer or Jobber and Dealer	Place of Sampling.	Protein. Found.	Protein. Guaranteed.	Fat. Found.	Fat. Guaranteed.	Fiber.
	American Cereal Co., Chicago, Ill.		%	%	%	%	%
2112	J. A. Lydecker	Paterson	14.16	13.00	6.36	5.00	4.10
2196	Hopkins & Williams	Newton	13.55	13.00	7.24	5.00	10.75
2319	Mundy Bros	Metuchen	13.31	13.00	5.66	5.00	8.57
	Average		13.67	13.00	6.42	5.00	7.86

YELLOW MEAL.

Station number.	Manufacturer or Jobber and Dealer	Place of Sampling.	Protein. Found.	Protein. Guaranteed.	Fat. Found.	Fat. Guaranteed.	Fiber.
	Miner-Hilliard Milling Co., Wilkesbarre, Pa.						
2323	Van Zant & Voorhees	Plainfield	10.64	9.27	4.10	6.25	2.41

MARSDEN FEED, NO. 1.

Station number.	Manufacturer or Jobber and Dealer	Place of Sampling.	Protein. Found.	Protein. Guaranteed.	Fat. Found.	Fat. Guaranteed.	Fiber.
	The Marsden Co., Philadelphia, Pa.						
2309	Wilkinson, Gaddis & Co	Newark	13.65	11.02	5.05	4.88	12.00

FEED MIXTURES.

GUARANTEED LOCAL FEED MIXTURES.

Station number.	Manufacturer or Jobber and Dealer.	Ingredients.	Protein. Found.	Protein. Calculated.	Fat. Found.	Fat. Calculated.	Fiber.
			%	%	%	%	%
2220	Belv dere Flour Mills Co., Belvidere, N. J...	....	9.99	9.80	2.44	3.10	5.36
2225	N. Dufford, Hackettstown, N. J.....	....	9.76	8.86	3.10	3.45	2.28
2224	N. Dufford, Hackettstown, N. J. (City Feed)...	Corn ears and oat tailings................	8.78	8.01	2.11	3.61	*4.03
2108	J. English, Paterson, N J...........	Hominy, oat chop, rye middlings.......	11.13	10.68	7.01	7.24	7.96
2234	R. Harden, Hamburg, N. J...........	....	12.28	10.00	7.42	5.00	4.08
2218	W. H. Ingersoll, Hamburg, N. J.....	....	15.28	9.50	4.69	3.00	2.45
2044	C. H. Kirby, Medford, N. J. (Dairy Feed)...	Corn and cob, and wheat bran...........	14.75	12.48	3.92	3.24	7.33
2240	J. B. Keener, Belvidere, N. J........	....	10.79	10.00	3.67	3.00	1.52
2242	W. Larison, Washington, N. J........	....	11.31	8.91	4.45	3.65	3.62
2248	G. K. & O. H. McMurtrie, Belvidere, N. J...	....	10.10	10.00	3.57	3.00	1.88
2184	[1]J. C. Smith & Wallace Co., Newark, N J. (Company Feed)...	Hominy, barley feed, oat hulls	11.44	10.00	5.90	4.00	7.55
2491	[2]Taylor Bros., Camden, N. J. (Dairy Feed, No. 2)...	Corn, light oats wheat bran, cockle and rice hulls.......	11.68	12.62	4.05	3.06	8.36
2282	[3]F. C. Williams, Easton, Pa..........	Rye middlings, corn, oats..............	10.88	10.01	5.67	4.98	2.74
	Average..............................	....	11.39	10.07	4.46	3.87	4.54

[1] Stock of John Fost, Passaic.
[2] Stock of C. C. Lippincott, Salem.
[3] Stock of Kynor & Looker, Boonton.

FEED MIXTURES.

UNGUARANTEED LOCAL FEED MIXTURES.

Station number.	Manufacturer or Jobber and Dealer.	Ingredients.	Protein. Found.	Protein. Calculated.	Fat. Found.	Fat. Calculated.	Fiber.
			%	%	%	%	%
2125	Campbell, Morrell & Co., Passaic, N. J. (No. 1)	Hominy, middlings corn meal, oat hulls, red dog, corn hulls salt	14.21	11.6	6.84	6.5	5.64
2128	Campbell, Morrell & Co., Passaic, N. J. (Fancy)	Corn, oats, hominy, rye, oat hulls, salt	10.65	9.6	8.78	4.3	8.92
2289	A. Cyphers, Newark, N. J.	Hominy, Vim oats, red dog	10.89	12.8	6 50	6.8	7.55
2229	J. Gardner, Dover, N. J.	Hominy, oat feed, red dog	12.74	11.5	5.89	5.6	6.00
2133	*Hemion Coal and Grain Co., Passaic, N. J.*	Corn, wheat bran and middlings	14.10	10.4	4.90	8.1	4.63
2020	Higgins Bros., Three Bridges, N. J.	Corn, wheat, oat hulls	10.68	9.0	3.52	3.1	1.76
2406	Hoffman & Radcliff, Frenchtown, N. J.	....	11.18	....	1.69	....	8.12
2091	Holley & Smith, Hackensack, N. J.	Chiefly hominy chop	11.94	11.8	6.38	6.1	2.71
2109	[1] *J. A. Lydecker, Paterson, N. J.*	Hominy, Vim oats, Victor corn and oats	11.02	9.8	6.42	7.2	6.70
2120	Long Dock Mills and Elevator Co., *Jersey City, N. J.*	....	10.79	....	5.58	....	2.60
2277	[2] Martenis & Coleman, Chester, N. J.	Rye, oats, cob meal	8.01	10.5	3.50	2.4	6.04
2146	McDonalds & Fox, Branchville N. J.	Rye, corn, oats, hominy, red dog	13.66	9.2	7.11	4.1	3.41
2095	Meyer & DeVogel, Paterson, N. J.	Hominy, oat feed, middlings	11.02	8.9	6.98	6.0	5.75
2278	[3] Miller & Mott, Rockaway, N. J.	Hominy, flour middlings, oat feed	12.17	10.8	5.86	7.1	4.49
2343	D. Neff, North Branch, N. J.	....	11.48	....	3.31	....	6.73
2257	The Chas. Richards Co., Dover, N. J.	Corn oat chop, rye chop, flour middlings, red dog	13.31	11.2	4.52	4.1	5.33
2128	J. & H. Steinberg, Passaic, N. J.	Hominy, oat feed	8.91	8.1	8.89	6.6	10.41
2575	Stults Bros., Trenton, N. J.	Corn, oats, bran	11.54	10.4	4.92	4.3	3.80
2306	Wilkinson, Gaddis & Co., Newark, N. J.	Corn, Marsden Feed, No. 1, and Marsden Feed, No. 2	9.94	8.9	3.94	3.5	3.66
	Average	....	11.45	10.2	5.42	5.1	5.19

[1] Stock of R. J. O'Brien, Passaic.
[2] *Stock of E. B. Dawson, Boonton.*
[3] Stock of M. M. Crane, Boonton.

FEED MIXTURES.

Oat Feeds and Corn and Oat Feeds.

QUAKER DAIRY FEED.

Station number.	Manufacturer or Jobber and Dealer.	Place of Sampling.	Protein. Found.	Protein. Guaranteed.	Fat. Found.	Fat. Guaranteed.	Fiber.
	American Cereal Co., Chicago, Ill.		%	%	%	%	%
2028	C. H. Kirby	Medford	17.17	14.00	8.89	8.50	12.68
2161	Hopkins & Williams	Newton	15.58	14.00	4.50	8.50	14.49
2265	Jaqui & Co.	Morristown	15.64	12.08	4.01	2.50	14.59
2818	H. Nischwitz & Co.	Plainfield	15.45	12.08	3.79	2.50	16.51
2420	Davis, Colson & Co.	Woodstown	17.11	14.00	4.10	8.50	11.04
2557	Stults Bros.	Trenton	15.88	12.08	4.84	2.50	14.65
2812	Mundy Bros.	Bound Brook	15.07	14.00	4.65	8.50	18.42
2400	E. V. Parry	Clinton	15.18	13.00	4.37	3.25	13.69
2754	Estate J. W. Biddle	Columbus	15.65	14.00	4.24	8.50	18.28
	Average		15.85	*14.00	4.21	*8.50	18.81

VICTOR CORN AND OAT FEED.

	American Cereal Co., Chicago, Ill.						
2077	C. B. Demarest	Hackensack	9.26	9.00	4.98	4.00	12.04
2111	J. A. Lydecker	Paterson	9.20	9.00	4.67	4.00	11.80
2208	G. O. Young	Tranquility	9.56	8.25	4.51	2.75	9.77
2815	Mundy Bros.	Bound Brook	9.69	9.00	4.69	4.00	10.09
2816	A. L. Cadmus	Plainfield	10.24	9.00	4.89	4.00	10.43
2422	Peterson & Smith	Woodstown	8.83	8.28	4.42	8.00	10.75
2527	J. E. Stevenson Co.	Trenton	9.87	9.00	4.70	4.00	9.08
2585	T. C. Dugan	New Brunswick	9.82	8.28	4.58	8.00	9.89
2677	G. W. Norton	Hightstown	9.69	8.75	4.85	8.75	11.94
2817	H. Nischwitz & Co.	Plainfield	9.58	8.75	4.68	8.75	11.80
2711	W. D. Rogers & Co.	Moorsetown	10.01	9.00	4.88	4.00	10.07
	Average		9.56	*9.00	4.70	*4.00	10.69

VIM OAT FEED.

	American Cereal Co., Chicago, Ill.						
2027	J. R. Wilkinson	Vincentown	7.22	6.80	2.75	2.38	25.90
2117	J. A. Lydecker	Paterson	8.56	6.80	2.91	2.38	24.90
2284	A. Cyphers	Newark	6.61	6.80	2.91	2.38	27.00
2384	R. B. Beatty	North Branch	8.44	6.80	3.20	2.38	24.85
	Average		7.71	6.80	2.94	2.38	25.66

* Guarantee filed by manufacturer.

FEED MIXTURES.

Oat Feeds and Corn and Oat Feeds—Continued.

DE FI CORN AND OAT FEED.

Station number.	MANUFACTURER OR JOBBER AND DEALER.	PLACE OF SAMPLING.	PROTEIN.		FAT.		Fiber.
			Found.	Guaranteed.	Found.	Guaranteed.	
	Elsworth & Co., Buffalo, N. Y.		%	%	%	%	%
2468	J. K. Waddington	Salem	8.68	8.80	3.08	3.00	18.74

FISH & CO.'S OAT FEED.

	Fish & Co., New York City.						
2066	P. O'Blenis	Paterson	9.79	1.00	3.65	1.00	15.25

FRIENDS' FEED.

	Great Western Cereal Co., Chicago, Ill.						
2826	C. F. French	Plainfield	10.70	10.90	4.07	3.70	16.69
2060	Sharpless & Bro	Camden	*8.65	*10.09	*3.62	*3.07	*20.52
	Average		10.70	10.90	4.07	3.70	16.69

BOSS CORN AND OAT FEED.

	The Great Western Cereal Co., Chicago, Ill.						
2183	Simmons & Martin	Deckertown	8.26	7.94	4.13	4.18	13.83
2269	Jaqui & Co	Morristown	9.81	7.94	4.73	4.18	13.45
	Average		9.04	7.94	4.43	4.18	13.64

ROYAL OAT FEED.

	Great Western Cereal Co., Chicago., Ill.						
2176	C. A. Wilson Co	Deckertown	7.71	8.25	2.54	4.14	26.50
2270	Jaqui & Co	Morristown	6.97	8.25	2.48	4.14	27.17
2472	J. K. Waddington	Salem	7.36	8.25	2.84	4.14	23.74
	Average		7.35	8.25	2.62	4.14	25.80

* *Omitted from the average.*

FEED MIXTURES.

Oat Feeds and Corn and Oat Feeds—Continued.

H. O. DAIRY FEED.

Station number.	Manufacturer or Jobber and Dealer.	Place of Sampling.	Protein. Found.	Protein. Guaranteed.	Fat. Found.	Fat. Guaranteed.	Fiber.
	The H. O. Co., Buffalo, N. Y.		%	%	%	%	%
2293	A. Cyphers	Newark	18.46	18.00	4.74	4.50	12.50
2317	C. F. French	Plainfield	19.86	18.00	4.19	4.50	9.91
	Average		19.16	18.00	4.47	4.50	11.21

H. O. HORSE FEED.

Station number.	Manufacturer or Jobber and Dealer.	Place of Sampling.	Protein. Found.	Protein. Guaranteed.	Fat. Found.	Fat. Guaranteed.	Fiber.
	The H. O. Co., Buffalo, N. Y.						
2089	Vile & Son	Jersey City	14.71	12.00	5.84	4.50	8.26
2291	A. Cyphers	Newark	13.26	12.00	4.27	4.50	10.28
2701	J. S. Middleton	Camden	15.27	12.00	6.29	4.50	6.22
2786	Colkitt & Thomson	Mount Holly	15.33	12.00	6.54	4.50	7.82
	Average		14.64	12.00	5.56	4.50	8.15

MONARCH OAT CHOP.

Station number.	Manufacturer or Jobber and Dealer.	Place of Sampling.	Protein. Found.	Protein. Guaranteed.	Fat. Found.	Fat. Guaranteed.	Fiber.
	Husted Milling and Elevator Co., Buffalo, N. Y.						
2099	J. E Lovet & Son	Hackensack	9.32	10.40	3.56	3.27	9.67
2187	Simmons & Martin	Deckertown	8.45	10.40	3.62	3.27	7.94
	Average		8.89	10.40	3.59	3.27	8.81

TAYLOR BROS.' OAT FEED.

Station number.	Manufacturer or Jobber and Dealer.	Place of Sampling.	Protein. Found.	Protein. Guaranteed.	Fat. Found.	Fat. Guaranteed.	Fiber.
	Taylor Bros., Camden, N. J.						
2068	B. M. Beideman	Merchantville	8.49	8.50	3.78	2.75	20.80

FEED SUBSTITUTES.

INDEPENDENCE OAT FEED.

Station number.	Manufacturer or Jobber and Dealer.	Place of Sampling.	Protein. Found.	Protein. Guaranteed.	Fat. Found.	Fat. Guaranteed.	Fiber.
	Fish & Co., New York City.		%	%	%	%	%
2228	W. H. Ingersoll	Hamburg	3.30	....	1.06	....	31.74

HILDEBRANDT'S OAT FEED.

Station number.	Manufacturer or Jobber and Dealer.	Place of Sampling.	Protein. Found.	Protein. Guaranteed.	Fat. Found.	Fat. Guaranteed.	Fiber.
	The Hildebrandt Co., Elizabeth, N. J.						
2364	J. Van Buren	Rahway	4.84	....	1.72	....	30.04

RANG'S OAT FEED.

Station number.	Manufacturer or Jobber and Dealer.	Place of Sampling.	Protein. Found.	Protein. Guaranteed.	Fat. Found.	Fat. Guaranteed.	Fiber.
	Henry Rang & Son, Chicago, Ill.						
2052	Taylor Bros	Camden	3.51	3.50	1.68	2.75	28.36
2441	H A. Fish	Woodbury	6.18	....	2.29	....	25.84
	Average		4.85	....	1.99	....	27.10

SITLEY'S OAT FEED.

Station number.	Manufacturer or Jobber and Dealer.	Place of Sampling.	Protein. Found.	Protein. Guaranteed.	Fat. Found.	Fat. Guaranteed.	Fiber.
	Sitley & Son, Camden, N. J.						
2062	Sitley & Son	Camden	2.54	3.75	0.78	2.56	32.48

MARSDEN FEED, NO. 2.*

Station number.	Manufacturer or Jobber and Dealer.	Place of Sampling.	Protein. Found.	Protein. Guaranteed.	Fat. Found.	Fat. Guaranteed.	Fiber.
	The Marsden Co., Philadelphia, Pa.						
2810	Wilkinson, Gaddis & Co	Newark	4.03	....	1.28	....	28.42

RICE MEAL.†

Station number.	Manufacturer or Jobber and Dealer.	Place of Sampling.	Protein. Found.	Protein. Guaranteed.	Fat. Found.	Fat. Guaranteed.	Fiber.
	Simpson, Hendee & Co., New York City.						
2281	Jaqui & Co	Morristown	2.14	2.56	0.92	1. 0	33.88
2580	Trenton Mills and Elevator Co	Trenton	3.67	2.56	1.66	1.00	29.94
	P. H. Van Wagoner & Co., Philadelphia, Pa.						
2291	A. Cyphers	Newark	2.26	2.56	0.90	1.00	35.82
2104	J. English	Paterson	3.67	2.56	1.32	1.00	32.90
	Average		2.94	....	1.20	....	33.50

CORNALINE.‡

Station number.	Manufacturer or Jobber and Dealer.	Place of Sampling.	Protein. Found.	Protein. Guaranteed.	Fat. Found.	Fat. Guaranteed.	Fiber.
	Fish & Co., New York City.						
2811	Fish & Co	Bound Brook	2.43	1.00	0.68	1.00	58.79
2569	Stults Bros	Trenton	2.94	1.00	0.48	1.00	69.69
	Average		2.69	....	0.58	....	58.24

* Cornstalks, ground after removing the pith.

† A misnomer; actually rice hulls.

‡ The inner hull of the coffee berry.

CALF MEAL AND GROUND MEAT.

AMERICAN CALF MEAL.

Station number.	Manufacturer or Jobber and Dealer.	Place of Sampling.	Protein. Found.	Protein. Guaranteed.	Fat. Found.	Fat. Guaranteed.
	American Cereal Co., Chicago, Ill.		%	%	%	%
2528	J. E. Stevenson Co.	Trenton	17.24	18.00	7.81	5.00

BLATCHFORD'S CALF MEAL.

	John W. Barwell, Waukegan, Ill.					
2185	A. N. Roe	Branchville	26.18	26.00	5.60	5.00
2565	Trenton Mills and Elevator Co	Trenton	25.14	*32.00	4.69	5.00
	Average		25.66	26.00	5.15	5.00

BAUGH'S GROUND BEEF SCRAP.

	Baugh & Sons' Co., Philadelphia, Pa.					
2032	Taylor Bros	Camden	56.69	57.12	17.54	16.50
2542	S. L. Pancoast	Mullica Hill	53.96	57.12	18.19	16.50
	Average		55.33	57.12	17.87	16.50

BLATCHFORD'S POULTRY MEAT.

	John W. Barwell, Waukegan, Ill.					
2551	C. A. Reed	Pennington	28.76	23.56	11.62	10.02

BOWKER'S ANIMAL MEAL.

	Bowker Fert. Co., Boston, Mass.					
2425	D. F. Hendrickson	Woodbury	34.61	30.00	9.87	5.00
2339	Vroom & Butler	Somerville	36.29	30.00	14.80	5.00
	Average		35.45	30.00	12.34	5.00

BOWKER'S BEEF SCRAP.

	Bowker Fert. Co., Boston, Mass.					
2461	Fithian & Pennell	Bridgeton	53.41	30.00	18.31	20.00
2004	James Halpin	Elizabeth	52.23	30.00	20.26	20.00
	Average		52.82	30.00	19.29	20.00

*Omitted from the average.

POULTRY FEED.

AMERICAN POULTRY FEED.

Station number.	Manufacturer or Jobber and Dealer.	Place of Sampling.	Protein. Found.	Protein. Guaranteed.	Fat. Found.	Fat. Guaranteed.	Fiber.
	American Cereal Co., Chicago, Ill.		%	%	%	%	%
2172	C. A. Wilson Co.	Deckertown	14.59	18.96	6.57	5.49	8.81
	H. O. POULTRY FEED.						
	The H. O. Co., Buffalo, N. Y.						
2019	Geo. Benedict	Elizabeth	19.86	17.00	5.64	5.50	4.83
2090	Holley & Smith	Hackensack	17.91	17.00	5.67	5.50	4.84
2589	J. E. Stevenson Co.	Trenton	18.27	17.00	5.74	5.50	4.98
2734	Hopkins & Lippincott	Moorestown	18.36	17.00	5.13	5.50	4.59
	Average		18.60	17.00	5.55	5.50	4.81
	POULTRY FEED.						
	Hopkins & Lippincott, Moorestown, N. J.						
2741	Hopkins & Lippincott	Moorestown	24.11	18.00	8.21	9.00	6.69
	RICE'S POULTRY FEED.						
	Hopkins & Lippincott, Moorestown, N. J.						
2740	Hopkins & Lippincott	Moorestown	24.74	15.00	9.09	8.00	4.80

WHEAT.

WINTER WHEAT BRAN.

Station number.	MANUFACTURER, JOBBER OR DEALER.	PLACE OF SAMPLING.	Protein	Fat.	Fiber
			%	%	%
2335	W. N. Adair & Co., Raritan, N. J.	Raritan	15.74	4.52	6.61
2582	A. K. Ashby, Burlington, N. J.	Burlington	16.13	4.52	7.40
2152	M. F. Barringer, Philadelphia, Pa.	Branchville	15.00	5.04	7.94
2031	B. M. Beideman, Merchantville, N. J.	Merchantville	14.83	5.06	6.67
2656	C. T. Birkett, Penn Yan, N. Y.	Long Branch	14.92	3.56	8.50
2512	Cornwall & Silvers, Fairton, N. J.	Fairton	15.38	4.68	6.92
2010	Cranford Flour and Feed Store, Cranford, N. J.	Cranford	15.45	4.65	4.99
2428	Davis, Colson & Co., Woodstown, N. J.	Woodstown	14.71	3.90	8.08
2467	Ewen Milling Co., Alloway, N. J.	Alloway	14.71	3.55	7.90
2470	Fithian & Pennell, Bridgeton, N. J.	Bridgeton	16.03	5.00	7.68
2014	Flemington Milling Co., Flemington, N. J.	Westfield	16.36	5.07	7.21
2692	H. A. Ford, Allentown, N. J.	Allentown	*13.14	*4.89	*7.06
2475	W. O. Garrison, Bridgeton, N. J.	Bridgeton	16.07	4.10	8.16
2367	Harter Milling Co., Toledo, O.	Perth Amboy	16.20	3.89	8.01
2342	H. E. Hawk, Easton, Pa.	North Branch	17.24	5.50	8.50
2433	Hires & Co., Quinton, N. J.	Quinton	†14.58	†5.28	†10.10
2092	Holley & Smith, Hackensack, N. J.	Hackensack	16.75	5.48	9.08
2485	Clinton Kelty, Salem, N. J.	Salem	17.28	5.84	9.38
2409	J. W. Kennedy, Shelbyville, Ind.	Everittstown	16.76	3.82	8.32
2704	G. H. Kirby, Allentown, N. J.	Allentown	15.49	4.73	5.43
2705	W. J. Koch & Co., Philadelphia, Pa.	Gloucester	16.24	4.42	....
2208	Lafayette Milling Co., Easton, Pa.	Andover	17.26	4.82	7.70
2394	Andrew Lane, Neshanic, N. J.	Neshanic	15.58	4.19	5.50
2489	F. H. Lloyd, Salem, N. J.	Salem	14.98	4.68	7.90
2640	J. G. Macky, Philadelphia, Pa.	Red Bank	17.79	4.93	7.87
2744	Milburn Mills, Philadelphia, Pa.	Moorestown	16.64	4.90	7.09
2438	G. B. Mitchell, Swedesboro, N. J.	Swedesboro	15.17	3.65	7.77
2869	Monticello Mills, Monticello, Ind.	Perth Amboy	15.78	4.20	8.86
2832	National Milling Co., Minneapolis, Minn.	Plainfield	16.88	3.99	6.68
2345	David Neff, North Branch, N. J.	North Branch	15.16	3.74	7.37
2254	Pursel Milling and Coal Co., Phillipsburg, N. J.	Phillipsburg	14.44	4.18	6.87
2440	Quaker City Milling Co., Philadelphia, Pa.	Woodbury	16.18	4.69	6.14
2397	A. S. Rockafellow, Flemington, N. J.	Flemington	17.33	3.68	7.17
2055	Sharpless & Bro., Camden, N. J.	Camden	15.63	4.20	7.51
2058	Sitley & Son, Camden, N. J.	Camden	15.89	4.82	6.70
2491	R. W. Smith, Elmer, N. J.	Elmer	17.83	4.88	9.49
2302	J. C. Smith & Wallace Co., Newark, N. J.	Newark	16.81	5.24	8.98
2612	C. H. Snyder & Son, Freehold, N. J.	Marlboro	14.89	4.66	7.02
2445	W. I. Stiles, Haddonfield, N. J.	Haddonfield	14.28	4.77	7.06
2622	H. E. Taylor, Englishtown, N. J.	Englishtown	14.54	4.88	6.19

*Omitted from the average—contains corn.

†Omitted from the average—contains oats, weed seed and cockle.

WHEAT.

WINTER WHEAT BRAN—Continued.

Station number.	Manufacturer, Jobber or Dealer.	Place of Sampling.	Protein.	Fat.	Fiber.
			%	%	%
2070	Taylor Bros., Camden, N. J	Camden	16.96	4.84	7.67
2501	L. W. Tomlinson, Bridgeton, N. J	Bridgeton	15.69	4.24	8.12
2418	Trenton Mills and Elevator Co., Trenton, N. J	Titusville	17.29	6.81	6.45
2499	J. K. Waddington, Salem, N. J	Salem	15.88	4.53	8.86
2526	Washburn-Crosby Co., Minneapolis, Minn.	Vineland.	17.04	5.26	9.84
2451	Johathan Webster, Woodstown. N J	Woodstown	14.05	5.12	6.76
2126	Wilkinson, Gaddis & Co., Newark, N. J	Passaic	16.40	4.47	7.78
2166	C. A. Wilson Co., Deckertown, N. J	Deckertown	18.44	5.54	7.56
2664	J. P. Wyckoff, Manasquan, N. J	Manasquan	16.88	4.54	5.79
	Average		15.96	4.68	7.61

SPRING WHEAT BRAN.

Station number.	Manufacturer, Jobber or Dealer.	Place of Sampling.	Protein.	Fat.	Fiber.
2460	M. F. Barringer, Philadelphia, Pa	Elmer	17.86	4.98	9.88
2589	Cambridge Milling Co., Minneapolis, Minn	New Brunswick	16.99	4.84	8.25
2324	L. Christian & Co., Minneapolis, Minn	Bound Brook	16.82	5.71	10.20
2675	A. A. Cortelyou, Neshanic, N. J	Neshanic	16.82	5.27	9.12
2290	A. Cyphers, Newark, N. J	Newark	*15.18	*5.05	*18.76
2408	Daisy Roller Mills, Milwaukee, Wis	Stockton	16.48	4.78	8.82
2341	Diamond Mills, Buffalo, N. Y.	Raritan	16.64	5.17	8.59
2227	Empire Grain and Elevator Co., Binghamton, N.Y.	Hamburg	16.18	4.97	7.64
2102	Joseph English, Paterson, N. J	Paterson	16.64	5.21	8.21
2197	Hart & Iliff, Newton, N. J	Newton	16.45	5.41	10.15
2362	The Hildebrandt Co., Elizabeth, N. J	Rahway	17.06	5.68	7.75
2384	B. Hoffman, Ringoes, N. J.	Ringoes	17.61	5.22	9.17
2382	L. L. Holcombe, Flemington, N. J	Flemington	17.79	4.78	7.78
2131	Hollister, Chase & Co., New York City	Passaic	16.69	5.02	8.46
2700	J. C. Hopkins, Moorestown, N. J	Camden	15.84	4.67	8.50
2788	Hopkins & Lippincott, Moorestown, N. J	Moorestown	17.78	5.54	9.45
2108	Howell & Webster, Middletown, N. Y.	Paterson	17.26	5.81	9.27
2664	E. C. Hutchinson Mill Co., Trenton, N. J	Pennington	16.86	5.05	9.79
2387	J. H. Jones & Co., Lambertville, N. J	Lambertville	17.49	5.77	9.25
2122	Long Dock Mills and Elevator Co., Jersey City, N. J	Passaic	16.92	5.24	9.50
2599	J. G. Macky, Philadelphia, Pa	New Brunswick	16.18	5.19	10.00
2250	Montevideo Roller Mill Co., Minneapolis, Minn	Dover	17.04	5.57	8.46
2021	The Northwestern Cons. Mill Co., Minneapolis	Elizabeth	16.29	5.11	10.06
2260	Pilsbury Flour Co., Minneapolis, Minn	Morristown	16.08	4.89	9.37
2136	A. N. Roe, Branchville, N. J	Branchville	17.19	5.75	8.46
2528	Sharpless & Bro., Camden, N. J	Vineland	16.88	5.18	9.96
2598	Sheffield Milling Co., Faribault, Minn	New Brunswick	16.86	5.51	8.88
2666	Simpson, Hendee and Co., New York City	Medford	16.84	5.28	8.44
2547	Taylor Bros., Camden, N. J	Mullica Hill	17.28	5.08	9.92
2077	Trenton Mills and Elevator Co., Trenton, N. J	Trenton	18.61	6.91	6.68

* Omitted from the average—contains coffee hulls (cornaline).

WHEAT.

SPRING WHEAT BRAN—Continued.

Station number.	Manufacturer, Jobber or Dealer.	Place of Sampling.	Protein.	Fat.	Fiber.
			%	%	%
2581	C. W. Wagar & Co., Philadelphia, Pa.	Trenton	16.49	5.29	7.82
2418	Washburn-Crosby Co., Minneapolis, Minn.	Frenchtown	18.84	5.11	7.06
2075	Wilkinson, Gaddis & Co., Newark, N. J.	Vincentown	16.57	5.28	8.47
2218	G. O. Young, Tranquility, N. J.	Tranquility	17.70	5.32	8.63
	Average		16.97	5.27	8.81

UNCLASSIFIED WHEAT BRAN.

Station number.	Manufacturer, Jobber or Dealer.	Place of Sampling.	Protein.	Fat.	Fiber.
2219	Belvidere Flouring Mills Co., Belvidere, N. J.	Belvidere	16.71	4.19	7.82
2717	Chapin & Co., Philadelphia, Pa.	Moorestown	16.80	4.31	7.87
2271	A. E. Howe, Newark, N. J. (Canadian)	Morristown	15.82	4.51	8.87
2241	J. B. Keener, Belvidere, N. J.	Belvidere	16.81	4.74	8.11
2543	S. L. Pancoast, Mullica Hill, N. J.	Mullica Hill	17.44	5.19	8.41
2022	C. Pountney, Elizabeth, N. J.	Elizabeth	17.02	5.52	10.12
2617	W. N. Steward, Englishtown, N. J.	Englishtown	17.52	4.61	8.17
2548	A. Thompson, Trenton, N. J.	Burlington	17.52	5.18	6.98
	Average		16.83	4.78	8.28

WHEAT FEED.

Station number.	Title.	Manufacturer, Jobber or Dealer.	Place of Sampling.	Protein.	Fat.	Fiber.
				%	%	%
2267	Buckeye	American Cereal Co., Chicago, Ill.	Morristown	17.88	5.00	6.13
2401	Buckeye	American Cereal Co., Chicago, Ill.	Clinton	17.12	4.67	6.24
2150		M. F. Barringer, Philadelphia, Pa.	Branchville	17.26	4.88	6.44
2177	Royal	Brooks-Griffiths Co., Minneapolis, Minn.	Deckertown	17.60	5.45	8.12
2361	Winter	Hecker-Jones-Jewell Milling Co., New York City	Perth Amboy	17.24	4.89	8.00
2156	Jersey	Kentucky Milling Co., Henderson, Ky.	Newton	*13.86	*4.10	*12.92
2144		A. Meurer & Co., Milwaukee, Wis.	Branchville	18.38	5.67	7.06
2245	King	R. P. Moore Mill Co., Princeton, Ind.	Hamburg	16.86	4.28	7.58
2165	Angola	Simpson, Hendee & Co., New York City	Deckertown	17.98	5.78	7.22
2170	Snow's	E. S. Woodworth & Co., Minneapolis, Minn.	Deckertown	17.99	6.08	7.47
2618	Low Grade Wheat	Wm. N. Steward, Englishtown, N. J.	Englishtown	†11.11	†2.15	†1.88
2621	Damaged Wheat	H. K. Taylor, Englishtown, N. J.	Englishtown	†14.66	†4.92	†5.24
	Average			17.52	5.18	7.13

WHEAT.

WHEAT MIDDLINGS (SHORTS).

Station number.	TITLE.	MANUFACTURER, JOBBER OR DEALER.	PLACE OF SAMPLING.	Protein.	Fat.	Fiber.
				%	%	%
2655	Winter	C. T. Birkett, Penn Yan, N. Y	Long Branch	15.84	4.15	3.71
2742	Flour Middlings	Hopkins & Lippincott, Moorestown, N. J	Moorestown	15.88	3.58	1.77
2395	Flour Middlings	Andrew Lane, Neshanic, N. J	Neshanic	15.29	4.25	2.15
2450	White Middlings	Jonathan Webster, Woodstown, N. J	Woodstown	15.28	3.25	1.15
2466	Shorts	Ewen Milling Co., Alloway, N. J	Quinton	*13.08	*2.57	*1.49
2618	Shorts	C. H. Snyder & Son, Freehold, N. J	Marlboro	*12.37	*2.88	*1.48
2665	Shorts	M. Wyckoff, Howell, N. J	Manasquan	14.28	4.00	2.91
	Average			15.21	3.85	2.84

BROWN MIDDLINGS.

2365	Brown	The Hildebrandt Co., Elizabeth, N. J	Rahway	18.71	6.90	7.66
2637	Brown	Long Dock Mills and Elevator Co., Jersey City, N. J	Matawan	*13.94	*4.48	*14.56
2189	Brown	The Northwestern Cons. Mill Co., Minneapolis, Minn	Branchville	18.21	5.31	8.58
2447	Brown	W. I. Stiles, Haddonfield, N. J	Haddonfield	18.91	7.08	2.85
	Average			18.61	6.43	6.35

FEEDING FLOUR.

2505	Fancy White Middlings	W. S. Ankeny & Co., Minneapolis, Minn	Vineland	19.38	4.73	4.31
2323	Red Dog	L. Christian & Co., Minneapolis, Minn	Bound Brook	19.88	5.81	....
2272	Red Dog	Jaqui & Co., Morristown, N. J	Morristown	20.58	5.61	....
2750	Red Dog	Washburn-Crosby Co., Minneapolis, Minn	Moorestown	21.24	5.72	....
2636	Low Grade Shorts	Washburn-Crosby Co., Minneapolis, Minn	Hightstown	21.22	5.98	3.20
2685	Adrian	Washburn-Crosby Co., Minneapolis, Minn	Hightstown	22.61	6.01	....
2644	Adrian	Wilkinson, Gaddis & Co., Newark, N. J	Matawan	20.25	5.31	....
2753	White Middlings	Wilkinson, Gaddis & Co., Newark, N. J	Mount Holly	19.53	5.30	1.54
2569	Flour Middlings	Wilkinson, Gaddis & Co., Newark, N. J	West End	21.71	6.30	2.46
	Average			20.71	5.64	....

*Omitted from averages—contains rice hulls.

BUCKWHEAT, RYE AND BARLEY.

BUCKWHEAT BRAN.

Station number.	Manufacturer, Jobber or Dealer.	Place of Sampling.	Protein.	Fat.	Fiber.
			%	%	%
2244	Wm. Larison	Washington	*36.36	10.19	5.00
2579	Trenton Mills and Elevator Co	Trenton	†16.06	4.78	22.52
2074	J. R. Wilkinson	Vincentown	†19.29	5.51	15.12
2169	C. A. Wilson Co	Deckertown	22.62	6.66	6.80

BUCKWHEAT FEED.

2415	Jos. Smith & Co	Stockton	‡27.69	7.45	2.05
2808	Wilkinson, Gaddis & Co	Newark	16.51	4.60	5.65

RYE BRAN.

2049	W. G. Kirby	Medford	14.10	3.64	3.84
2768	J. N. Smith & Bro	Pemberton	14.14	3.42	3.05
	Average		14.12	3.53	3.45

RYE MIDDLINGS.

	Hottelet & Co., Milwaukee, Wis.				
2285	W. H. Ingersoll	Hamburg	16.81	3.64	4.13

RYE FEED.

2690	H. A. Ford	Allentown	9.76	2.50	1.99
2609	D. E. Mahoney	Keyport	10.33	2.11	1.44
2619	W. N. Steward	Englishtown	9.04	1.92	1.40
2620	H. E. Taylor	Englishtown	9.04	1.84	1.21
	Average		9.54	2.09	1.51

BARLEY FEED.

	J. C. Smith & Wallace Co., Newark, N. J.				
2800	J. C. Smith & Wallace Co	Newark	16.76	4.48	4.70

* Contains peanut meal.
† Contains an excess of hulls.
‡ More properly "middlings."

CORN.

CORN MEAL.

Station number.	Manufacturer, Jobber or Dealer.	Place of Sampling.	Protein.	Fat.
			%	%
2836	W. N. Adair & Co., Raritan, N. J	Raritan	8.66	3.88
2755	[1] T W. Ashby, Florence, N. J	Columbus	9.04	3.87
2402	[2] J. H. Ashton, Trenton, N. J.	Titusville	9.05	3.89
2583	Henry Banker, New Brunswick, N. J	New Brunswick	9.98	4.34
2759	Estate J. W. Biddle, Columbus, N. J	Columbus	8.78	3.71
2009	[3] A. L. Cadmus, Plainfield, N. J	Dunellen	9.48	4.85
2321	A. L Cadmus, Plainfield, N. J	Plainfield	8.44	3.65
2129	Campbell, Morrell & Co., Passaic, N. J	Passaic	9.25	4.98
2622	Carlan & Devlin, Matawan, N. J	Matawan	9.87	3.97
2633	W. A. *Close, Matawan*, N. J	*Matawan*	8.81	4.86
2727	Colkitt & Thomson, Mount Holly, N. J	Mount Holly	8.49	5.42
2518	H. Cornell, Vineland, N. J	Vineland	8.15	3.98
2511	Cornwall & Silvers, Fairton, N. J	Fairton	8.82	4.08
2145	C. H. Crisman, Branchville, N. J	Branchville	8.78	3.82
2568	[4] Dayton Milling Co., Towanda, Pa.	Trenton	9.81	4.30
2689	C. C. Dempsey, Gloucester, N. J	Gloucester	8.09	4.82
2856	[5] Diamond Mills, Buffalo, N. Y	Perth Amboy	8.81	4.18
2857	Thos. Eggert & Co., Perth Amboy, N. J	Perth Amboy	9.79	4.38
2015	[6] Flemington Milling Co., Flemington, N. J	Westfield	9.64	4.09
2514	[7] T. C. Fox, Willow Grove, N. J	Vineland	8.67	4.31
2478	W. O. Garrison, Bridgeton, N. J	Bridgeton	8.95	5.18
2657	John Guire & Bro., West End, N. J	West End	10.10	4.66
2016	James Halpin, Elizabeth, N. J	Elizabeth	9.58	4.38
2233	Reeves Harden, Hamburg, N. J	Hamburg	9.18	4.49
2368	[8] Higgins Bros., Three Bridges, N. J	Perth Amboy	8.74	4.52
2868	[9] The Hildebrandt Co., Elizabeth, N. J	Rahway	9.79	4.71
2885	B. *Hoffman, Ringoes*, N. J	*Ringoes*	8.74	4.91
2182	[10] Hollister, Chase & Co., New York City	Passaic	8.80	3.23
2485	[11] J. C. Hopkins, Moorestown, N. J	Haddonfield	8.61	5.47
2789	Hopkins & Lippincott, Moorestown, N. J	Moorestown	8.78	5.62
2217	W. H. Ingersoll, Hamburg, N. J	Hamburg	9.42	3.79
2388	J. H. Jones & Co , Lambertville, N. J	Lambertville	9.06	4.17
2604	J. W. Keough, Keyport, N. J	Keyport	9.18	3.96
2047	*C. H.* Kirby, Medford, N. J	Medford	9.25	4.77
2890	F. F. Lear, Lambertville, N. J	Lambertville	9.48	4.30
2094	Long Dock Mills and Elevator Co., Jersey City, N. J	Jersey City	9.86	3.82
2147	McDonalds & Fox, Branchville, N. J	Branchville	9.86	4.60

[1] Stock of T. S. Page & Co.
[2] Stock of H. W. Van Artsdalen.
[3] Stock of A. Gray.
[4] Stock of Stults Bros.
[5] Stock of J. J. Nash.
[6] Stock of R. F. Hobenstein.
[7] Stock of Sheard & Brooks.
[8] Stock of Petty & Applegate.
[9] Stock of J. Van Buren.
[10] Stock of Passaic Feed Co.
[11] Stock of H. A. & G. H. Clement.

CORN.

CORN MEAL—Continued.

Station number	MANUFACTURER, JOBBER OR DEALER.	PLACE OF SAMPLING.	Protein.	Fat.	Fiber.
			%	%	%
2749	G. K. & O. H. McMurtrie, Belvidere, N. J.	Belvidere	9.66	4.12	....
2487	G. B. Mitchell, Swedesboro, N. J.	Swedesboro	9.91	4.00	....
2346	David Neff, North Branch, N. J.	North Branch	8.68	3.56	....
2684	G. W. Norton, Hightstown, N. J.	Hightstown	9.07	4.90	....
2410	E. V. Parry, Clinton, N. J. (Western)	Clinton	9.29	4.34	....
2555	C. A. Reed, Pennington, N. J.	Pennington	9.07	4.18	....
2519	[1]A. K. Richmond & Bro., Malaga, N. J.	Vineland	8.88	3.34	....
2398	A. S. Rockafellow, Flemington. N. J.	Flemington	8.88	5.21	....
2308	J. C. Smith & Wallace Co., Newark, N. J.	Newark	8.84	4.92	....
2615	C. H. Snyder & Son, Freehold, N. J.	Freehold	8.53	3.61	....
2545	J. E. Stevenson Co., Trenton, N. J.	Trenton	9.87	4.21	....
2708	[2]Taylor Bros., Camden, N. J.	Camden	9.04	4.57	....
2073	J. R. Wilkinson, Vincentown, N. J.	Vincentown	8.58	3.02	....
2647	[3]Wilkinson, Gaddis & Co., Newark, N. J.	Red Bank	9.59	4.81	....
2288	[4]F. C. Williams, Easton, Pa.	Boonton	8.82	4.88	....
2862	J. P. Wyckoff, Manasquan, N. J.	Manasquan	10.05	4.02	....
	Average		9.09	4.82	....

LOW GRADE CORN MEAL.

2724	J. S. Collins & Son, Moorestown, N. J.	Moorestown	6.89	2.23	....
2429	H. A. Fish, Woodbury, N. J.	Woodbury	5.28	1.85	....
2703	G. H. Kirby, Allentown, N. J.	Allentown	7.58	3.91	....
2058	Sharpless & Bro., Camden, N. J.	Camden	6.61	3.62	....
2769	J. N. Smith & Bro., Pemberton, N. J.	Pemberton	7.79	3.70	....
2416	D. R. Worman, Frenchtown, N. J.	Frenchtown	*8.74	2.03	....
285[illegible]	W. H. H. Wyckoff, Raritan, N. J.	Raritan	*8.13	1.79	....

CORN EAR OR COB MEAL.

2340	R. B. Beatty, North Branch, N. J.	North Branch	7.20	1.57	4.45
2222	Belvidere Flour Mills Co., Belvidere, N. J.	Belvidere	7.56	3.91	5.86
2344	David Neff, North Branch, N. J.	North Branch	7.71	2.21	5.60
2205	S. S. Wills, Andover, N. J.	Andover	8.13	3.06	3.88
2349	W. H. H. Wyckoff, Raritan, N. J.	Raritan	7.53	2.80	5.06
	Average		7.63	2.71	4.77

[1] Stock of Klure & Niggin.
[2] Stock of J. S. Middleton.
[3] Stock of F. D. Wikoff.
[4] Stock of Kynor & Looker.
* Contains traces of cob.

WHOLE GRAINS GROUND TOGETHER.

CORN AND OATS.

Station number.	MANUFACTURER, JOBBER OR DEALER.	PLACE OF SAMPLING.	Protein.	Fat.	Fiber.
			%	%	%
2597	[1] P. E. Apgar, Weston, N. J.	New Brunswick	9.89	3.98	2.41
2587	Henry Banker, New Brunswick, N. J.	New Brunswick	9.96	3.97	2.20
2008	[2] A. L. Cadmus, Plainfield, N. J.	Westfield	9.97	4.09	2.68
2083	Carscallen & Cassidy, Jersey City N. J.	Jersey City	*9.78	*3.44	*9.77
2681	Cartan & Devlin, Matawan, N. J.	Matawan	*8.78	*4.19	*6.61
2012	Cranford Flour and Feed Store, Cranford, N. J.	Cranford	10.10	3.56	3.41
2180	[3] Diamond Mills, Buffalo, N. Y.	Passaic	*9.91	*5.58	*7.46
2358	Thos. Eggert & Co., Perth Amboy, N. J.	Perth Amboy	9.58	4.47	1.74
2469	Fithian & Pennell, Bridgeton, N. J.	Bridgeton	10.04	4.89	2.05
2360	[4] Flemington Milling Co., Flemington, N. J.	Rahway	9.76	4.19	1.86
2691	H. A. Ford, Allentown, N. J.	Allentown	9.87	3.50	1.80
2325	C. F. French, Plainfield, N. J.	Plainfield	8.67	1.74	2.80
2474	W. O. Garrison, Bridgeton, N. J.	Bridgeton	11.25	4.94	2.85
2685	[5] Higgins Bros., Three Bridges, N. J.	Red Bank	10.21	4.08	1.09
2365	[6] The Hildebrandt Co., Elizabeth, N. J.	Rahway	9.99	4.00	3.04
2363	L. L. Holcombe, Flemington, N. J.	Flemington	9.07	2.00	2.71
2605	J. W. Keough, Keyport, N. J.	Keyport	9.53	3.75	1.60
2702	G. H. Kirby, Allentown, N. J.	Allentown	9.18	3.15	1.22
2608	[7] Long Dock Mills and Elevator Co, Jersey City	Keyport	11.08	5.28	4.92
2683	G. W. Norton, Hightstown, N. J.	Hightstown	10.21	4.28	2.07
2412	E. V. Parry, Clinton, N. J.	Clinton	10.84	4.69	1.68
2372	Petty & Applegate, Perth Amboy, N. J.	Perth Amboy	10.38	4.88	2.17
2514	C. H. Snyder & Son, Freehold, N. J.	Freehold	8.70	4.84	1.76
2264	W. Stull & Bro., Madison, N. J.	Madison	12.91	4.98	5.00
2502	L. W. Tomlinson, Bridgeton, N. J.	Bridgeton	10.65	3.73	1.88
2643	[8] Wilkinson, Gaddis & Co., Newark, N. J.	Matawan	9.34	2.74	2.69
2663	J. P. Wyckoff, Manasquan, N. J.	Manasquan	10.28	4.56	1.56
	Average		10.05	3.92	2.30

[1] Stock of C. W. Russell.
[2] Stock of R. F. Hohenstein.
[3] Stock of Passaic Feed Co.
[4] Stock of J. H. Jennings.
[5] Stock of B. Hance.
[6] Stock of J. Van Buren.
[7] Stock of D. R. Mahoney.
[8] Stock of W. A. Close.
* Omitted from the average—contains an excessive amount of oat hulls.

WHOLE GRAINS GROUND TOGETHER.

MISCELLANEOUS GRAINS.

Station number.	Manufacturer, Jobber or Dealer.	Ingredients.	Protein.	Fat.	Fiber.
			%	%	%
2837	W. N. Adair & Co., Raritan, N. J	Corn, oats, rye	10.97	3.85	2.74
2146	C. H. Crisman, Branchville, N. J	Corn, rye, oats, wheat	11.28	4.59	2.47
2018	[1]Flemington Milling Co., Flemington, N.J.	Corn, oats, wheat screenings	10.56	4.66	1.82
2288	J. S. Hance, Hackettstown, N. J.	Rye, corn and cob, oats	8.83	2.87	2.62
2408	Joseph Huff, Everittstown, N. J.	Corn, rye oats	9.87	1.97	1.48
2278	Jaqui & Co., Morristown, N. J.	Corn, rye, oats	9.93	3.54	3.48
2891	F. F. Lear, Lambertville, N. J.	Corn, rye, oats	9.76	4.69	1.78
2256	Pursel Mill and Coal Co., Phillipsburg, N.J.	Corn, rye, oats	12.86	3.30	3.10
2549	A. S. Rockafellow, Flemington, N. J		9.75	4.55	1.41
2261	H. D. White & Son, Beattystown, N. J.	Corn, rye, oats	11.56	1.59	3.85
2153	[2]W. O. Williams, Portland, Pa.	Corn, rye, oats	9.82	2.77	1.74
2204	S. S. Wills, Andover, N. J	Cob meal, rye, oats	9.96	2.66	1.97
2171	C. A. Wilson Co., Deckertown N. J.	Corn, rye, oats	10.42	3.22	2.28
	Average		10.43	3.41	2.28

MISCELLANEOUS MATERIALS.

FLAXSEED MEAL.

Station number.	Manufacturer, Jobber or Dealer.	Place of Sampling.	Protein.	Fat.	Fiber.
			%	%	%
2057	Sitley & Son	Camden	*17.29	30.10	....
2576	Trenton Mills and Elevator Co	Trenton	26.74	31.24	....

‡WHEAT BRAN AND OIL.

	American Can Co., Baltimore, Md.				
2775	Wm. Diecks	Orange	14.54	8.01	....
2776	Kynor & Looker	Boonton	16.88	7.57	....
2777	W. L. Smith	Livingston	15.29	8.19	....
	Average		15.40	7.92	....

SUGAR BEET PULP.

	Binghamton Beet Sugar Co., Binghamton, N. Y.				
2773	S. P. Tomkins (user)	Franklin Furnace	†1.08	0.09	....

‡NUTRIUM MILK POWDER.

	National Nutrient Co., Jersey City, N. J.				
2778	Geo. Roe (user)	Augusta	33.81	0.66	....

[1] Stock of R. F. Hohenstein, Westfield.
[2] Stock of S. Hill, Newton.

* Contains wheat.
† Contains 89.85 per cent. of water.
‡ See next page.

Wheat Bran and Oil.

This is a waste product from the manufacture of tin plate. The following account of its origin is abstracted from Thorpe's Dictionary of Applied Chemistry, as follows:

The sheets to be tinned are dipped in melted grease, such as tallow or palm oil, until all moisture has been removed and they are uniformly coated with grease. They are next dipped into the tin pot, which contains melted tin covered with a layer of grease. The sheets now receive their first coating of tin, which, however, is not perfect; after a number of manipulations to render it so, they are then cleaned from grease, usually by rubbing with bran and finishing with the woolly skin of a sheep. In France, chopped rice straw is used for cleaning the sheets, but American manufacturers have been generally content to copy the methods adopted in South Wales.

By the above process the wheat bran, according to the samples received, has acquired additional fatty matter to an amount about equal to that originally in it, without materially decreasing the content of protein. It also contains a small quantity of metallic tin, which has been brushed from the plates in the form of small scales and clots. If a small portion of the bran is stirred to a thin paste in a glass of water, the bran may be floated off and the tin will settle and become visible at the bottom of the glass. The amount of tin in these samples was trifling, and no inconvenience from this source to the animals to which it has been fed has as yet been brought to our attention.

Nutrium Milk Powder.

This material is evaporated skim-milk, and, therefore, has a high protein content—33.81 per cent. It is manufactured by the National Nutrient Co., of Jersey City, N. J., at their factory at Augusta, N. J. The Station has received a statement from the company that it "is recovered from sweet skim-milk, no acids or chemicals or ingredients being used in its recovery, nor are any foreign ingredients mixed with it afterwards." This product is manufactured for human consumption, the principal customers being bakers and confectioners; but occasionally a day's product, or a batch, is unsatisfactory for the purpose intended, when it is sold as cattle food in the immediate locality of the factory.

II.

MARKET PRICES OF COMMERCIAL FEEDS.

The gathering of statistics concerning the average market prices f commercial feeds used in the State was begun in 1891. It has een continued since, though with some changes as to method. Up ɔ January 1st, 1900, the records represented the average price per ɔn for the six months preceding January 1st. Last year a change 'as made, which it is believed will more accurately represent the *cutal prices paid for feeds, since the average prices are of feeds* btained direct from dealers for analysis under the law passed in 900, and now in force. Besides, the averages now represent not nly a larger number of samples distributed more generally over the tate, but also a larger number of specific brands than have been ɔcluded in previous years. Hence a comparative study of composi-ion and prices cannot be made in all cases as yet.

The general tendency toward higher prices since January 1st, 1897, ; very apparent, the prevailing prices in the spring of 1902 being, enerally speaking, double what they were five years ago. The largest dvances have occurred within the past two years, and were due pri-ɔarily to the shortage of the corn crop, which caused that commodity ɔ advance in price 27 per cent. in 1900–01, and to further advance 1 per cent. in 1901–02. This has caused a sympathetic advance in *ll the rest of the list, particularly during the past year. The feeds* f high protein content, cottonseed, linseed, germ oil and gluten meal, dvanced least: the advance was $2.67 per ton, on the average. The rewery products advanced $3.93, on the average. The common by-roducts of the milling of wheat and rye advanced an average of $5.28 er ton. Feed mixtures with corn and light oats as a base advanced 6.22 per ton. Corn meal itself advanced $6.95, while maizeline feed, ɔrealine feed, cob meal, hominy meal and provender advanced $7.25, 7.94, $8.39, $8.72 and $8.79, respectively.

It is difficult to see why these by-products of corn should have ad-anced more than corn meal itself, especially as the advance is not hared in by corn bran (sugar feed), or the gluten feeds, which ad-anced but $4.05 and $5.43 per ton, respectively. The average advance ɔr all feeds was $5.74 per ton, or nearly 30 per cent. over 1900, at 'hich time it was 12 per cent. over the year before.

KIND OF FEED.	AVERAGE FOR THE SIX MONTHS PRECEDING— Jan. 1st, 1897.	Jan. 1st, 1898.	Jan. 1st, 1899.	Jan. 1st, 1900.	May 1st, 1901.	May 1st, 1902.
Cottonseed Meal	$22 40	$23 00	$20 22	$25 33	$28 70	$30 79
Linseed Meal	22 97	24 32	25 30	28 94	34 08	35 50
Germ Oil Meal	.....	.....	.....	.....	22 75	26 50
Chicago Gluten Meal	14 83	16 83	19 83	22 42	26 08	29 50
Gluten Feeds	12 00	15 22	15 92	18 41	21 87	27 30
Hominy Meal	12 75	13 94	15 94	17 00	19 05	27 77
Cerealine Feed	.....	.....	.....	.....	19 75	27 69
Maizeline Feed	.....	.....	.....	.....	19 50	26 75
Corn Bran, or Sugar Feed	.....	.....	.....	.....	17 10	21 15
Malt Sprouts	10 90	12 08	14 58	15 89	17 50	21 37
Dried Brewers' Grains	12 88	15 13	14 92	17 67	19 06	22 73
Dried Distillers' Grains	.....	.....	.....	.....	.....	21 67
Sucrene Dairy Feed	.....	.....	.....	.....	21 00	25 25
Schumacher Corn, Oats and Barley	.....	.....	.....	.....	20 00	30 75
Local Feed Mixtures	.....	.....	.....	.....	20 68	26 97
Quaker Dairy Feed	.....	.....	.....	.....	18 86	24 56
Victor Corn and Oat Feed	.....	.....	.....	.....	18 55	25 61
Vim Oat Feed	.....	.....	.....	.....	16 10	20 58
De Fi Corn and Oat Feed	.....	.....	.....	.....	19 00	25 00
Friend's Feed	.....	.....	.....	.....	16 13	23 25
Boss Corn and Oat Feed	.....	.....	.....	.....	.....	23 50
Royal Oat Feed	.....	.....	.....	.....	16 00	19 50
H. O. Dairy Feed	.....	.....	.....	.....	22 70	29 00
H. O. Horse Feed	.....	.....	.....	.....	21 88	29 99
Monarch Oat Chop	.....	.....	.....	.....	.....	26 00
Wheat Bran	12 81	14 10	15 43	17 48	21 13	25 95
Wheat Middlings	14 98	15 85	17 87	19 15	22 63	28 75
Brown Middlings	.....	.....	.....	.....	.....	27 00
Feeding Flour	.....	.....	.....	.....	.....	28 33
Wheat Feed	.....	.....	.....	.....	19 75	25 75
Buckwheat Bran	.....	.....	.....	.....	.....	22 00
Buckwheat Feed	.....	.....	.....	.....	.....	20 00
Rye Bran	11 13	12 44	14 69	17 22	17 50	23 00
Rye Middlings	14 40	15 50	16 97	18 60	18 00	25 00
Rye Feed	.....	.....	.....	.....	23 00	25 25
Corn Meal	14 83	15 02	16 62	17 25	22 00	28 95
Corn Ear Meal	12 60	13 67	15 92	14 33	15 41	23 80
Corn and Oats (Provender)	14 29	16 69	19 79	19 81	20 90	29 69
Mixed Grains	.....	.....	.....	.....	21.56	28.33

III.

LOSSES IN THE FAT OF CORN MEAL DUE TO THE ACTION OF MOULDS.

The shortage in the corn crop during the past season caused the farmers, in many cases, to dispose of their supply before it had become properly dried, and for the same reason the millers were obliged to grind the corn almost at once. As a result much of the corn meal on the market this year shows an abnormal content of moisture. This excess of moisture not only causes a decreased percentage in protein, fat and the other food compounds, but also by its presence encourages the growth of certain micro-organisms which have a deleterious effect on the food compounds of the meal.

Hebebrand[1] and Welte[2] have shown that pure cultures of *Penicilium glaucum* and *Aspergillus nidulus* acting on sterilized bread caused a great loss of dry matter, as much as 75 per cent., which was noted chiefly in the carbohydrates. The total nitrogen remained unaltered, although a part of the protein was converted into soluble nitrogen compounds. The fat and crude fiber showed a slight increase. Scherpe[3] has noted that with a marked moulding of rye and wheat there was a decided and almost proportionate decrease in all the food constituents. Reitmair[4] has called attention to the fact that in peanut cake the fat content was reduced by mould from 11.90 to 0.56 per cent. Klein[5] has observed in experiments on the preservation of olive press cake, that with a water content of 30 to 35 per cent. the fat content in three months decreased from 17.51 to 9.48 per cent., while the fatty acids rose from 1.18 to 73.11 per cent. Biffen[6] has found in cocoanuts a fungus under whose action the fat is dissipated. R. B. Schmidt[7] has shown that *Aspergillus niger* is nourished excellently with almond oil as the only source of carbohydrates, and that great amounts of it are destroyed. The mould thrives still better on free

[1] Landw. Vers. Stat., 1893, 43, 421.
[2] Arch. Hyg., 1895, 24, 84.
[3] Zeit. Nahr. und Genussm., 1899, 2, 550.
[4] Landw. Vers. Stat., 1891, 38, 386.
[5] Zeit. f. angew. Chem., 1900, 635.
[6] Ann. of Botany, 1899, 13, 363.
[7] Flora, 1891, 74, 300.

oleic acid. Rubner[1] has shown that the bacteria of the soil cause a breaking up and combustion of the fat. A pure soil bacteria culture in a solution of meat extract with calcium carbonate in one month destroyed 13.45 per cent. of the butter-fat present, and in one year 56.01 per cent. Spieckermann and Bremer[2] have made an extended study of the effect of moulds on cottonseed meal. Their experiments showed that, with a moisture content under 21 per cent., there was a marked destruction of fat; with 24 to 30 per cent. of moisture, complete destruction of carbohydrates marked loss of fat and slight losses of pentosans and protein; with 30 to 50 per cent. of moisture an increased destruction of protein, with the formation of ammonia, complete destruction of carbohydrates, increased loss of pentosans and a decreased loss of fat. A sample of cottonseed meal, in which the moulds were allowed to develop spontaneously, showed in a little less than six months an increase of moisture from 8.44 to 28.68 per cent. On the dry basis the fat decreased from 13.81 to 1.68 per cent., the free fatty acids increased from 10.70 to 52.10 per cent., and the total nitrogen and pentosans showed slight losses. The moulds which developed were *Eurotium repens, Eurotium rubrum, Penicilium glaucum* and *Monilia,* in the order named.

In the feed inspection this year the number of samples collected was so large that it was impossible to analyse them immediately on their receipt. When the time came for grinding the samples, it was found that nineteen of them were so mouldy and wet, although they had been tightly stoppered, that not only was grinding out of the question, but an analysis of such materials would be unfair and of little value. Accordingly those samples have been entirely omitted in our consideration. They included thirteen samples of corn meal, four of horse feeds, in which corn was the chief component, and one each of corn and oats and of cob meal.

In addition to these very mouldy samples, seventeen samples of corn meal were found which, to the sight, were apparently normal, but which gave out a mouldy odor, and, under the microscope, showed unmistakably the presence of micro-organisms, notably *Penicilium glaucum.* However, the decomposition had not progressed so far as to prevent analysis, and the results of this analysis are shown in the following table:

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[1] Arch. Hyg., 1900, 38, 67.

[2] Landw. Jahrb., 1902, 31, 81–127.

Deteriorated Corn Meal.

Protein.	Fat found.	Fat calculated.	Loss in fat.	Percentage loss in fat.	Protein.	Fat found.	Fat calculated.	Loss in fat.	Percentage loss in fat
%	%	%	%		%	%	%	%	
9.87	1.50	4.64	3.14	67.7	8.42	2.70	3.96	1.26	31.8
8.38	1.77	3.94	2.17	55.1	7.95	2.57	3.74	1.17	31.3
7.69	1.69	3.61	1.92	53.2	8.08	2.68	3.80	1.12	29.5
8.15	1.86	3.83	1.97	51.4	8.15	2.95	3.83	0.88	23.0
7.96	1.93	3.74	1.81	48.4	7.92	2.89	3.72	0.83	22.3
6.66	1.74	3.13	1.39	44.4	8.38	3.22	3.94	0.72	18.3
8.38	2.36	3.94	1.58	40.1	7.75	3.04	3.63	0.59	16.3
8.38	2.38	3.94	1.56	39.6	8.02	3.61	3.77	0.16	4.2
8.93	2.63	4.20	1.57	37.4	....	....	....	....	....

The examination of a large number of samples of normal corn meal at this Station has shown that on the average the percentage of fat present is 47 per cent. of the percentage of protein. It was felt, therefore, that for purposes of comparison it would not be unfair to assume that the samples above tabulated should contain an amount of fat equal to 47 per cent. of the protein found. The third column in the table was secured in this way, and the fourth and fifth columns show the deficiency from normal fat content and the percentage loss of fat, respectively.

It will be seen that these losses range from 67.7 to 4.2 per cent. An excess of moisture in the samples would cause a lower percentage of both protein and fat, but such is not here the case, as is shown particularly in the first sample, where with a protein percentage of 9.87, there is but 1.50 per cent. of fat, where normally there should be 4.64 per cent. These samples were examined under the microscope and no evidence of adulteration was detected, but the familiar mould, *Penicilium glaucum,* was found in abundance.

In order to determine whether this mould was the chief factor in causing the losses in fat noted, the following experiment was carried ont: A sample of normal corn meal was selected in which the moisture, fat and protein were determined. Four portions of two grams each were weighed into fat extraction tubes, and were inoculated with

Penicilium glaucum, and water added to secure the following percentages of moisture, 10.73, 14.98, 32.63 and 36.24. The action of the mould was continued for nine days at an average temperature of 71° Fahrenheit. The samples were then dried and protein and fat determined in them. The following table shows the results obtained:

Tests.		Water.	Protein.	Loss in protein.	Percentage loss.	Fat.	Loss in fat.	Percentage loss.
		%	%	%		%	%	
	Original sample..................	10.73	9.54	....	....	4.33	....	....
1	" " + mould....	10.73	9.31	0.23	2.41	4.25	0.08	1.85
2	" " " "	14.98	9.43	0.11	1.16	4.12	0.21	4.85
3	" " " "	32.63	9.08	0.46	4.82	3.87	0.46	10.62
4	" " " "	36.24	9.25	0.29	3.04	3.80	0.53	12.24

While the losses shown are not great, still it is noticeable, particularly in the case of the fat, that as the percentage of moisture is increased the loss of fat increases, in test four amounting to as much as 12.24 per cent. Pressure of work prevented continuing this experiment for a more extended period, but there is no doubt that if the time covered had been three, two, or even one month, the results would have been much more striking. Certain other results which were obtained incidentally on other samples seem to bear out this view. The low percentages of fat obtained in our first examination of certain samples cast some doubts upon the accuracy of the analysis, and new determinations were made to confirm them. It was found that in every case the new results were considerably lower and in some cases excessively low. The intervals elapsing between the different analyses naturally varied considerably, but the moisture content seemed to be the dominating factor rather than the time element.

Losses of Fat in Corn Meal.

No.	Water.	Fat. First test.	Fat. Last test.	Loss.	Percentage Loss.	Time elapsed between tests.
	%	%	%	%		
87	9.96	3.23	3.15	0.08	2.48	35 days.
128	10.72	4.71	4.33	0.38	8.07	49 "
43	12.21	3.62	3.07	0.55	15.19	66 "
412	13.92	2.23	1.70	0.53	23.77	18 "
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible] "

The table shows that with an increase of moisture content, and with consequent more favorable conditions for the development of the mould, a loss of fat is shown in every case, ranging from 8.07 to 53.31 per cent., omitting the first sample in which the water content was normal. It has been shown by other observers that not only does moisture favor the development of *Penicilium*, but that this development itself causes an increase in moisture. The effect of this is shown very strikingly in the case of sample 141 in the above table. On January 21st it showed 2.57 per cent. fat; on February 10th, twenty days later, 2.19 per cent. fat, and on March 10th, twenty-eight days later, only 1.20 per cent. fat, showing very clearly that with the increased development of the mould larger and quicker losses of fat occurred.

It was impossible in the limited time at our disposal to make a more extended study of the changes which the mould may have occasioned in the other food compounds of the corn meal, but a searching investigation of these problems is planned for the near future.

IV.

TWO NEW FEED ADULTERANTS.

The present inspection has disclosed the fact that there are two new adulterants in the New Jersey feed markets. The one consists of the hard, flinty hulls of the rice grain, sold under the misleading name of "rice meal;" the other of the inner hull of the coffee berry, sold under the even more misleading name of "cornaline." Four samples of the rice hulls and two of the cornaline, in an unmixed condition, were collected by our inspector during the present season. A careful inspection on the part of the purchaser would have shown at once the woody, fibrous nature of these materials, but when they are mixed with standard feeds, even in quite large proportions, their detection is a matter of much difficulty. That these inferior materials are used for the purpose of adulterating feeds of recognized value is evident from the fact that among the samples collected this year we find one sample of brown middlings, which consisted of nearly one-third rice hulls, and one sample of wheat bran that contained considerable cornaline, while a sample of linseed meal was received which consisted of over one-fourth rice hulls. That these are not isolated

cases is proved by our correspondence with other Stations, which shows that at least three of the eastern States have found during the present season similar adulterations. It is important that these adulterants should be readily recognized by Station workers, and for that purpose certain characteristic structures of these materials are pictured and described below.

Rice Hulls.

The samples sold under the name of rice meal this season were found to consist almost exclusively of the hard, dried, flinty hulls of the rice grain. The epidermal cells of the rice hull possess marked characteristics, whether viewed in a cross or in a tangential section, but as the latter are always present and will be observed more frequently, these alone are described here. The epidermal cells may be observed directly on the slide after soaking the fragments for several

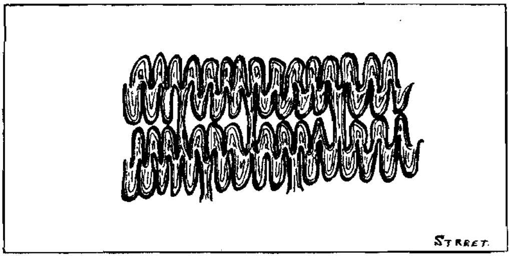

Fig. 1.
Rice hulls. Epidermal cells in chloral hydrate.

minutes in water, or still better after maceration with dilute potassium hydroxid, nitric acid or chloral hydrate. The last-named reagent was found particularly useful, as after a few minutes the cells became greatly swollen and were easily isolated. These cells are also readily colored by either an alcohol fuchsin solution or alkaline methylene blue.

The cells are arranged in several convoluted, ribbonlike rows, separated from each other by a narrow space except where occasionally a cell is lengthened out and joins the corresponding layer, as is

width and from 0.032 to 0.043 mm. in length, and are best observed with a magnification of from 250 to 300. These cells are very characteristic, are always present in rice hulls and afford a simple and easy means for their identification.

Coffee Hulls.

The dark-colored outer hulls of the coffee berry have long been employed as a coffee substitute under the name of "Sultan Coffee," but the use of the inner hull, the parchment-like endocarp, as an adulterant has been noticed this season for the first time. The material called "cornaline" has been found to consist almost entirely of the endocarp of the coffee hull, only an occasional fragment of the dark-colored outer hull being present. When finely ground this ma-

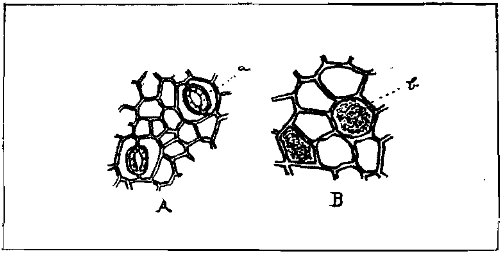

Fig. 2.

Coffee hulls. A. Epidermis, with stomata (a). B. Parenchyma, with minute crystals (b). In chloral hydrate. (After Tschirch.)

terial strongly resembles corn bran, and when mixed with wheat bran, several cases of which have been found, it can only be detected by the use of the microscope.

The fruit shell, or pericarp, of the coffee berry consists of five layers, an epidermis, a parenchyma, an obliterated layer, fibro-vascular bundles and a sclerotic layer (the endocarp).

The epidermis consists of rather small (0.033 mm.) polygonal cells, with straight, smooth walls, rather thickened on the outer side. There are no intercellular spaces, but stomata are frequently present, always surrounded by two cells placed in the shape of a crescent (Fig 2, A).

Underlying the epidermis is a parenchyma layer, consisting of

polygonal, isodiametric cells, with thick walls, and frequently containing aggregations of minute crystals. These cells are dark-brown or colorless, according to the portion of the hull which furnished them (Fig. 2, B).

Then follows an obliterated layer, the middle zone of the mesocarp, which adheres closely to the bast cells.

The *fibro-vascular bundles* consist of fibres of greatly varying shapes, about 1 mm. long, and from 0.020 to 0.025 mm. broad; they are found as tubes, ducts or long irregular fibres, with thick, pitted walls. The spiroids are long and narrow and generally thinner than the bast fibers.

The endocarp consists chiefly of irregular, sclerotic, spindle-shaped cells, crossing each other iu all directions, and with thick, channeled walls. These cells are quite thick in the outer layer, and are pierced by fine pore-canals; in the inner layer they are much thinner (Fig. 3).

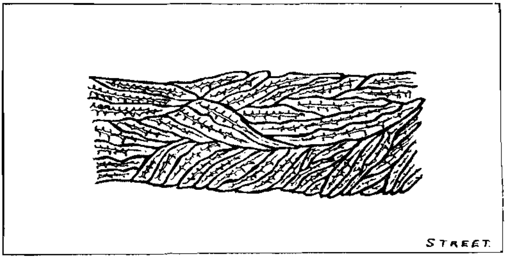

Fig. 3.

Coffee hulls. Sclerotic cells of the endocarp in chloral hydrate.

The structure of the sclerotic cells of the endocarp is very characteristic, and when viewed tangentially furnishes an easy means of detecting this form of adulteration. As in the case of the rice hulls, fragments may be observed directly after soaking for a short time in water, but more satisfactory results will be obtained by treatment with either potassium hydroxid or chloral hydrate, preferably the latter.

The accompanying cuts show in tangential section the characteristic structure of these cells, as well as the structure of the epidermis and parenchyma of the outer hulls, fragments of which will be found occasionally in the adulterant.

INVESTIGATIONS RELATIVE TO THE USE OF NITROGENOUS MATERIALS.

BY EDWARD B. VOORHEES.

These investigations were undertaken mainly to determine the relative availability and value of nitrogen in farm manure, and in the nitrogen salts and high-grade organic nitrogenous materials found in the market. In the study of these substances, there was also included the study of the changes which take place when farm-yard manures are exposed to the leaching action of rain. The changes in the manures thus exposed involve not only a loss of a portion of the fertilizing material originally contained in the manure, but they also cause a relative decrease in the availability of the portion still remaining. The soluble nitrogen, potash and phosphoric acid are very readily washed out from the unprotected manure, and the resources of the farmer for replacing the plant-food taken out of his soil by the crops are thus very materially diminished. Immense quantities of the most valuable plant-food constituents whose monetary value is great, are thus lost to the farmers of the United States. In order to determine the extent of these losses in manures, samples of cow manure of known composition and consisting of solid excreta alone, and of a mixture of solid and liquid excreta, were exposed for varying lengths of time, at the end of which they were analyzed and the results noted. The data thus obtained have been reported from time to time,[1] and the more recent analytical results presented here tend to confirm the experience of the other seasons.

The manure was carefully collected, and 100 pounds of each placed in a galvanized iron box, 8 inches deep, with a perforated bottom covered with wire gauze to prevent mechanical losses, and then exposed to the open air. Representative samples were taken from each lot, and analyzed in the laboratory. The manures were exposed from May 28th, 1901, until July 29th, 1901, that is, for a period of sixty-one days. At the end of that time the boxes were weighed, and representative samples taken and analyzed. The figures representing the analyses of the fresh and the leached manures were compared on the water-free basis, and the losses calculated.

[1] N. J. Sta. Reps., 1899, p. 97; 1900, p. 86; 1901, p. 144.

THE COMPOSITION OF THE SOLID AND OF THE SOLID AND LIQUID PORTIONS OF COW MANURE, FRESH.

As in the preceding years, the samples were obtained by collecting from a cow, well fed, a considerable amount of the solid manure, and of the solid and liquid manure, or total excrement. The samples were thoroughly mixed, and adequate portions taken for analysis. For the purposes of comparison, the analyses of the different samples used since the beginning of these experiments are given here:

Fresh Manure, Solid.

	1898. %	1899. %	1900. %	1900. %	1901. %
Water	85.081	85.103	85.011	85.103	84.977
Ash	1.815	2.325	1.776	2.608	2.928
Organic matter	13.104	12.572	13.213	12.289	12.095
Nitrogen (total)	0.341	0.312	0.319	0.355	0.364
" water-soluble	0.087	0.073	0.051	0.060	0.073
" as nitrates	0.015	0.026	....	....	Trace.
" as ammonia	0.037	0.013	....	0.012	0.038
" as soluble organic	0.035	0.034	0.051	0.048	0.035
" as insoluble organic	0.254	0.239	0.268	0.295	0.291
Phosphoric acid	0.434	0.330	0.347	0.279	0.364
Potash	0.222	0.188	0.211	0.128	0.266

Fresh Manure, Solid and Liquid.

	1898. %	1899. %	1900. %	1900. %	1901. %
Water	84.858	83.408	85.095	89.560	88.440
Ash	1.957	2.344	2.040	2.257	2.516
Organic matter	13.185	14.248	12.865	8.183	9.044
Nitrogen (total)	0.538	0.486	0.533	0.264	0.426
" water-soluble	0.284	0.220	0.280	0.088	0.214
" as nitrates	0.002	0.042	....	....	Trace.
" as ammonia	0.162	0.170	0.089	0.034	0.173
" as soluble organic	0.120	0.008	0.191	0.054	0.041
" as insoluble organic	0.254	0.266	0.253	0.176	0.212
Phosphoric acid	0.391	0.335	0.346	0.206	0.368
Potash	0.353	0.315	0.275	0.462	0.727

The analyses of the different years show comparatively slight variations. The total nitrogen in the solid fresh varies from .312 per cent. to .364 per cent., and the water-soluble from 0.51 per cent.

to .087 per cent., and in the solid and liquid, fresh, from .264 per cent. to .538 per cent. for the total nitrogen, and from .088 per cent. to .284 per cent. for the soluble nitrogen. As would be expected, the variations are greater in the latter case, for the moisture content is more variable here. Nitrates occur in very slight quantity, and in some cases are absent entirely. The ammonia nitrogen varies from .012 per cent. to .038 per cent. in the solid manures, and from .034 per cent. to .173 per cent. in the solid and liquid manures. The greater proportionate amounts of ammonia in the solid and liquid portions are due to the liquid manure, which furnishes ammonia when the hippuric acid and the urea contained in it are decomposed by bacteria. The amounts of soluble organic nitrogen are fairly uniform in the solid manures, but show considerable variations in the solid and liquid manures taken together. The amounts of phosphoric acid in the solid manures are, in the greater number of cases, rather constant, and do not differ much from the corresponding amounts in the solid and liquid portions taken together. On the other hand, there are very considerable differences in the potash content of the solid, and of the solid and liquid portions. In the former, it ranges from .128 per cent. to .266 per cent., in the latter from .275 per cent. to .727 per cent. This shows that very considerable quantities of potash are contained in the liquid manure.

The following tables give the composition of these manures, calculated on the water-free basis:

COMPOSITION OF MANURES ON WATER-FREE BASIS.

Solid, Fresh.

	1898. %	1899. %	1900. %	1900. %	1901. %
Ash	12.166	15.607	11.849	17.507	19.490
Organic matter	98 834	84.393	88.151	82.493	80.510
Nitrogen (total)	2.286	2.094	2.128	2.383	2.423
" water-soluble	0 583	0.490	0.340	0.403	0.486
" as nitrates	0.101	0.175	....	....	....
" as ammonia	0.248	0.087	....	0.081	0.253
" soluble organic	0.234	0.228	0.340	0.322	0.233
" insoluble organic	1.703	1.604	1.788	1.980	1.937
Phosphoric acid	2.915	2.215	2.315	1.873	2.423
Potash	1.488	1.899	1.408	0.859	1.771

Solid and Liquid, Fresh.

	1898.	1899.	1900.	1900.	1901.
	%	%	%	%	%
Ash	12.924	14.127	13 687	21.619	21.765
Organic matter	87.076	85.873	86.313	78.381	78.235
Nitrogen (total)	3 553	2.929	3.576	2.529	3.685
" water soluble	1.876	1.326	1.879	0.843	1.850
" as nitrates	0.013	0.253	....	....	....
" as ammonia	1.070	1.025	0.597	0.326	1.495
" soluble organic	0.793	0.048	1.282	0.517	0.355
" insoluble organic	1.677	1.603	1.697	1.686	1.835
Phosphoric acid	2.582	2.019	2.321	1.877	3.183
Potash	2.331	1.899	2 321	4.425	6.289

It will be noticed that there are considerable variations in the ash content of the dry matter. In the solid portion it varies from 11.849 per cent. to 19.490 per cent., with an average of 15.324 per cent., while in the solid and liquid portion it varies from 12.924 per cent. to 21.765 per cent., with an average of 16.824 per cent. Similarly in the case of the nitrogen content, there is a variation from 2.094 per cent. to 2.423 per cent., with an average of 2.263 per cent. in the solid portion, and a variation from 2.529 per cent. to 3.685 per cent., with an average of 3.254 per cent. in the solid and liquid portions. The average content of phosphoric acid in the dry matter of the solid manure is 2.348 per cent., and of the solid and liquid manure it is 2.396 per cent. The average content of potash in the dry matter of the solid manure is 1.485 per cent., and of the solid and liquid portion it is 3.453 per cent.

THE COMPOSITION OF THE SOLID AND OF THE SOLID AND LIQUID PORTIONS OF COW MANURE, LEACHED.

As was already stated, 100 pounds of each of the manures, whose analyses are given above, were exposed for different lengths of time. In each case the exposure resulted in the loss of greater or smaller quantities of the manures exposed. The following tabulation shows the time of exposure and the final weight of the samples:

Solid Manure.

	Original weight. lbs.	Exposed.	Final weight. lbs.
1898.	100	February 4th to June 15th = 131 days	50
1899.	100	February 3d to April 13th = 70 days	74
1900.	100	February 2d to April 20th = 76 days..........	73
1900.	100	August 9th to September 27th = 50 days.	62
1901.	100	May 28th to July 29th = 61 days..........	56.5

Solid and Liquid Manure.

1898.	100	February 4th to June 15th = 131 days..........	61
1899.	100	February 3d to April 13th = 70 days..........	71
1900.	100	February 2d to April 20th = 76 days..........	68
1900.	100	August 9th to September 27th = 50 days........	62
1901.	100	May 2d to July 29th = 61 days..........	34.5

The analyses of these residues, calculated on the water-free basis, show the following results:

Solid, Leached.

	1898. %	1899. %	1900. %	1900. %	1901. %
Ash..........	14.161	13.835	11.163	18.395	24.923
Organic matter..........	85.839	86.165	88.837	81.605	75.077
Nitrogen (total)..........	2.489	1.877	2.197	2.314	2.278
Nitrogen soluble in water.........	0.377	0.244	0.456	0.169	0.339
" as nitrates..........	0.058	....	....	....	....
" as ammonia..........	0.182	....	....	0.037	0.213
" as soluble organic......	0.137	0.244	0.456	0.132	0.126
" as insoluble organic....	2.112	1.633	1.741	2.145	1.939
Phosphoric acid..........	1.408	2.195	1.470	1.912	2.372
Potash..........	0.584	1.525	1.008	0.874	1.649

Solid and Liquid, Leached.

	1898. %	1899. %	1900. %	1900. %	1901. %
Ash..........	15.282	14.051	13.570	21.354	20.547
Organic matter..........	84.718	85.949	86.430	78.646	79.543
Nitrogen (total)..........	2.529	2.329	3.204	2.290	2.753
" soluble in water......	0.734	0.790	1.456	0.407	0.985
" as nitrates..........	0.014	....	....	....	....
" as ammonia..........	0.521	0.374	0.617	0.059	0.073
" as soluble organic....	0.199	0.416	0.839	0.348	0.912
" as insoluble organic..	1.795	1.539	1.748	1.883	1.768
Phosphoric acid..........	1.617	2.375	1.248	2.250	3.100
Potash..........	1.062	1.936	1.193	3.605	4.093

The average content of ash in the dry matter of the solid leached is 16.495 per cent., as against 15.324 per cent. in the dry matter of the solid fresh. The average content of ash in the dry matter of the solid and liquid leached is 16.961 per cent., as against 16.824 per cent. in the dry matter of the solid and liquid fresh. The average nitrogen content in the dry matter of the leached manures is less than that in the dry matter of the fresh manures. *In the solid fresh it is* 2.263 per cent., as against 2.233 per cent. in the solid leached. In the solid and liquid fresh it is 3.254 per cent., as against 2.621 per cent. in the solid and liquid leached. As might have been expected, the proportionate losses of nitrogen are greater from the solid and liquid manure on account of the greater proportion of soluble nitrogen originally contained in it. It is quite evident that where manures are exposed the soluble constituents would be the first to vanish. By comparing the relative amounts of soluble nitrogen in the dry matter of the solid fresh and leached, and of the solid and liquid fresh and leached, the extent of such losses under the conditions of the experiment will appear. In the dry matter of the solid manure fresh, the average content of water soluble nitrogen is .460 per cent., as against .317 per cent. in the dry matter of the solid manure leached. In the dry matter of the solid and liquid fresh it is 1.555 per cent., as against .854 per cent. in the dry matter of the solid and liquid manure leached. It is quite clear, then, *that the greater proportionate losses fall to the share of the soluble* constituents, which, by virtue of their solubility, are also the most valuable constituents of the manure. Before taking up the discussion of the *absolute* amounts lost from the manures exposed, it *will be of interest to compare the relative content of phosphoric acid* and of potash in the solid manures, fresh and leached, and in the solid and liquid manures, fresh and leached. It appears that the average content of phosphoric acid in the dry matter of the solid manure fresh is 2.348 per cent., as against 1.871 per cent. in the dry matter of the solid manure leached, and 2.396 per cent. in the solid and liquid portion fresh, as against 2.118 per cent. in the solid and liquid portion leached. In the case of potash, the corresponding figures are 1.485 per cent. for the solid fresh, and 1.128 per cent. for the solid leached, and 3.453 per cent. for the solid and liquid fresh, as compared with 2.378 per cent. for the solid and liquid leached.

Losses Sustained.

In the annual report for 1901 [1] the economic significance of the losses from farm-yard manures, due to leaching, is discussed at length, and it is, therefore, unnecessary to consider it here. For the sake of comparison with the more recent data, the absolute amounts of plant-food lost in the different years are again tabulated. The length of exposure determines to a great extent the amounts lost; none the less, the temperature and the season are very important factors here. Even at the low winter temperature slight changes take place in the composition of the manure exposed on account of the bacterial life in them, and as the temperature rises the activity of the bacteria is intensified, as are the decomposition losses accompanying such activity.

Solid Manure.

In 100 Pounds of Dry Matter.

Lot.	Period.		Ash.	Organic matter.	Nitrogen.	Phosphoric acid.	Potash.
1.	181 days.	Original ....lbs.....	12.166	87.834	2.296	2.915	1.488
		Loss..................lbs.....	5.085	44.915	1.041	2.211	1.196
		Per cent ....lost...	**41.8**	**51.1**	**46.0**	**72.0**	**80.0**
2.	70 days.	Original..........lbs.....	15.607	84.393	2.094	2.215	1.262
		Loss ....lbs.....	5.369	20.631	0.705	0.591	0.133
		Per cent.........lost...	**34.4**	**24.4**	**34.0**	**27.0**	**10.0**
3.	76 days.	Original..........lbs.....	11.849	88.151	2.128	2.315	1.468
		Loss ....lbs.....	3.700	23.300	0.524	1.242	0.672
		Per cent ....lost...	**31.2**	**26.4**	**25.0**	**54.0**	**48.0**
4.	50 days.	Original ....lbs.....	17.507	82.493	2.368	1.673	0.859
		Loss ....lbs.....	7.114	36.386	1.076	0.793	0.365
		Per cent..........lost...	**40.6**	**44.1**	**45.0**	**42.0**	**42.0**
5.	61 days.	Original..........lbs.....	19.490	80.510	2.423	2.423	1.771
		Loss ....lbs.....	4.038	33.962	1.011	0.952	0.749
		Per cent..........lost...	**20.0**	**42.0**	**42.0**	**39.0**	**42.0**
	Average original ....lbs.....		15.324	84.676	2.263	2.346	1.358
	Average loss		5.061	31.839	0.871	1.158	0.623
	Average per cent..................		**33.6**	**37.6**	**38.4**	**46.8**	**44.4**

[1] N. J. Sta. Rep., 1901, p. 147.

Solid and Liquid Manure Combined.

In 100 Pounds of Dry Matter.

Lot.	Period.		Ash.	Organic matter.	Nitrogen.	Phosphoric acid.	Potash.
1.	131 days.	Original.........lbs.....	12.924	87.076	3.553	2.582	2.331
		Loss.................lbs.....	3.602	35.893	2.010	1.594	1.684
		Per cent........ lost...	**27.8**	**40.6**	**57.0**	**62.0**	**72.0**
2.	70 days.	Original.........lbs.....	14.127	85.878	2.929	2.019	1.899
		Loss .... lbs.....	4.151	24.849	1.275	0.333	0.524
		Per cent........ lost...	**29.4**	**28.9**	**44.0**	**16.0**	**28.0**
3.	76 days.	Original........ lbs.....	13.687	86.813	3.576	2.321	1.846
		Loss.............. lbs.....	4.459	27.541	1.397	1.472	1.034
		Per cent .... lost...	**32.6**	**31.9**	**39.0**	**63.0**	**56.0**
4.	50 days.	Original........ lbs.....	21.619	78.381	2.529	1.877	4.425
		Loss.............. lbs.....	14.252	51.248	1.739	1.108	3.181
		Per cent........ lost...	**65.9**	**65.4**	**69.0**	**59.0**	**72.0**
5.	61 days.	Original........ lbs.....	21.765	78.235	3.685	3.183	6.289
		Loss.............. lbs.....	9.026	28.974	1.978	1.261	3.751
		Per cent........ lost...	**41.0**	**37.0**	**54.0**	**40.0**	**60.0**
	Average original ....lbs.....		16.824	83.176	3.254	2.396	3.358
	Average loss ....lbs.....		7.098	33.602	1.679	1.152	2.085
	Average per cent....... lost...		**30.3**	**40.7**	**52.6**	**48.0**	**57.6**

In all cases but one, the loss, both relative and absolute, was *greater from the solid and liquid manure when taken together than* it was from the solid manure alone. The absolute loss of phosphoric acid was about the same, although there was a *relatively* greater loss from the solid and liquid manure when taken together. The loss of nitrogen varied from 25 per cent. to 46 per cent. in the solid manure, and from 39 to 69 per cent. in the solid and liquid manure. The loss of potash varied from 10 per cent. to 80 per cent. in the solid manure, and from 28 to 72 per cent. in the solid and liquid manure. An examination of the table will show that the greatest absolute losses from the solid manure of ash and nitrogen took place in lot 4, notwithstanding the fact that the length of exposure in this case was far shorter than in the case of lot 1, for instance. In lot 1, the length of the exposure was 131 days, in lot 4 it was only 50 days. The differences in the solid and liquid manures, leached, are in some instances even more striking. In lot 4 there was lost in 50 days 14.25 pounds of ash, or 65.9 per cent. of the amount originally present, and 51.25 pounds of organic matter, or 65.4 per cent. of the amount originally present. In lot 1, where

the length of exposure was so much greater, the corresponding losses were 3.60 pounds and 35.40 pounds, or 27.8 per cent. and 40.6 per cent., respectively, of the amount originally present. It appears from this that the mere leaching action of rain is not sufficient in itself to account for all the losses which take place. There is another factor here which deserves attention, namely, the action of bacteria. Remembering that lots 4 and 5 were exposed during the warmer months, when *the activity of the lower organisms is intense*, it becomes clear why the absolute losses are at times greater during the shorter periods. On the other hand, lots 1, 2 and 3 were exposed *during the period covered* by the months of February, March and April (in the case of lot 1, also, May and part of June), when the activity of the lower organisms is slight. This activity has a two-fold effect on the manures under consideration. In the first place, the breaking down of the organic matter results in the formation of volatile substances, which includes ammonia and free nitrogen. As would be expected, the losses due to this would involve the organic portion of the manure. In the second place, the bacteria, by breaking *down the organic molecules, render a considerable portion of the* manure soluble, and, therefore, subject to the leaching action of rain. The mineral portion of the manure, not being volatile, cannot be decreased in quantity unless it is rendered soluble, and then washed out by the rain. The tables show clearly that there was a proportionately greater loss of organic matter and of nitrogen during the shorter, warmer periods. In order to bring this out more graphically, the average daily losses in the different lots, both solid *and solid and liquid, are tabulated.* It would be expected that with a sufficient amount of rain-fall, the soluble constituents present in the manure would be washed out very rapidly, and that the subsequent losses would be very gradual and comparatively slight. From this it follows that the solid and liquid portions combined would show greater proportionate losses during the shorter periods than would be shown by the solid manure alone. These losses would be further increased by the greater activity of the bacteria in the *solid and liquid* portions, which, being richer in moisture and soluble organic substances, offer a more favorable medium for their development. An examination of the following tables will easily *prove these contentions.*

Loss Per Day of Ash.

Lot.	Length of Exposure, Days.	Solid, lbs.	Solid and Liquid, lbs.
1	131	.039	.027
2	70	.077	.059
3	76	.048	.059
4	50	.142	.285
5	61	.066	.116

Loss Per Day of Organic Matter.

1	131	.343	.270
2	70	.295	.355
3	76	.306	.362
4	50	.728	1.025
5	61	.557	.475

Loss Per Day of Nitrogen.

1	131	.008	.015
2	70	.010	.018
3	76	.007	.018
4	50	.021	.035
5	61	.017	.032

Loss Per Day of Phosphoric Acid.

1	131	.017	.012
2	70	.008	.005
3	76	.016	.019
4	50	.016	.022
5	61	.016	.021

Loss Per Day of Potash.

1	131	.009	.013
2	70	.002	.008
3	76	.009	.014
4	50	.007	.064
5	61	.012	.062

The daily losses of ash from the solid and the solid and liquid portions do not show great differences until we come to lots 4 and 5, where the differences are very considerable. Thus the daily loss of ash from lot 1 is .039 pounds in the solid, and .027 pounds in the solid and liquid, while in lot 4 the corresponding losses are .142 and .285 pounds, and in lot 5 they are .066 and .116 pounds. To a slighter extent, the same is true of the other constituents. It will be noticed, furthermore, that the daily losses from the solid manure of more volatile phosphoric acid and potash are rather uniform, irrespective of the length of the exposure. Thus the daily losses of phosphoric acid from lots 1, 3, 4 and 5 are .017, .016, .016 and .016 pounds, respectively. In the case of organic matter of the solid manures, the daily losses from lots 1, 2, 3, 4 and 5 are .343, .295, .306, .728 and .557 pounds, respectively. The same is true of the nitrogen. In all cases, the greatest average daily loss was from lot 4, whose exposure was shortest, and, with a few exceptions, the smallest average daily loss secured in lot 1, whose exposure was the longest. In lot 1 there was a greater daily loss of ash, organic matter and phosphoric acid from the solid portion than there was from the corresponding solid and liquid portion, and a smaller daily loss of nitrogen and potash from the solid portion than there was from the solid and liquid portion combined.

Description of the Experiment Plant.

A detailed description of the experiment plant will be found in the report for 1899,[1] but for the sake of clearness the diagram of the experiment is given here again.

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[1] N. J. Sta. Rep., 1899, pp. 104–106.

Diagram of Experiment.

Series.	A	B	C
1. Check	○	○	○
2. Minerals	○	○	○
3. Manure, solid, fresh	○	○	○
4. Manure, solid and liquid, fresh	○	○	○
5. Manure, solid, leached	○	○	○
6. Manure, solid and liquid, leached	○	○	○
7. Nitrate of soda, 5 gms	○	○	○
8. Nitrate of soda, 10 gms	○	○	○
9. Manure, solid, fresh; nitrate, 5 gms	○	○	○
10. Manure, solid, fresh; nitrate, 10 gms	○	○	○
11. Manure, solid and liquid, fresh; nitrate, 5 gms	○	○	○
12. Manure, solid and liquid, fresh; nitrate, 10 gms	○	○	○
13. Manure, solid, leached; nitrate, 5 gms	○	○	○
14. Manure, solid, leached; nitrate, 10 gms	○	○	○
15. Manure, solid and liquid, leached; nitrate, 5 gms	○	○	○
16. Manure, solid and liquid, leached; nitrate, 10 gms	○	○	○
17. Sulfate of ammonia	○	○	○
18. Dried blood	○	○	○
19. Manure, solid, leached; sulfate of ammonia	○	○	○
20. Manure, solid, leached; dried blood	○	○	○

Composition of the Manures Used.

The manures used in the fall of 1900 had the following compositions:

	Solid, Fresh.	Solid and Liquid, Fresh.	Solid, Leached.	Solid and Liquid, Leached.
	%	%	%	%
Water	84.339	85.228	78.135	77.864
Ash	2.207	2.101	4.022	4.727
Organic matter	13.454	12.671	17.843	17.409
Nitrogen, total	0.367	0.426	0.506	0.507
" soluble in water	0.042	0.150	0.037	0.090
" as nitrates	....	....	....	....
" as ammonia	0.039	0.095	0.008	0.013
" as soluble organic	0.003	0.055	0.029	0.077
" as insoluble organic	0.325	0.276	0.469	0.417
Phosphoric acid	0.349	02.44	0.418	0.498
Potash	0.279	0.260	0.191	0.801

Application of Manures and Fertilizers.

The manures and fertilizers were applied on October 3d, 1900. After careful weighing, the manure was thoroughly incorporated with the soil in the following manner: About one-half of the upper soil was first removed from the cylinder, the manure was placed in a tin pan, and a measured quantity of water poured over it, and stirred until the whole mass was in a semi-liquid state. The contents of the pan were then distributed uniformly over the exposed area, the consistency of the mass permitting a very even distribution. Such a procedure was more satisfactory than the old method of mixing the manure with the soil, for in the latter case the manure was distributed in the soil in lumps, in spite of the care taken to prevent this. After the addition of the manure, the soil that had been removed was again returned to the cylinder and the fertilizer was evenly distributed over the surface and the soil stirred.

Amounts Applied.

It was the aim to have the different kinds of manure applied uniformly in amount and slightly greater than would be used in ordinary practice, and corresponding with that frequently used in market

gardening. The application was in no case so excessive as to render the condition different from those obtaining in good farm practice, or at the rate of 16 tons per acre.

In the case of nitrogen in artificial forms, the nitrates only were applied in two different quantities, in the one case 5 grams per cylinder, equivalent to 160 pounds per acre, which may be regarded as a medium, and in the second, 10 grams per cylinder, equivalent to 320 pounds per acre, or a large application. This was done in order that the effect of denitrification, if any, might be more fully studied. *In the case of ammonia and blood, an amount of nitrogen* equivalent to that in the larger quantities of nitrate was used.

The Crops Grown.

The crop grown on the loam soils was wheat, and that was followed by timothy. The conditions under which the first crop was grown were somewhat different than those of the preceding years. The season was longer and included the winter months. Naturally, the temperature, the moisture and the chemical and biological conditions being different, gave rise to results not always concordant with those of the other seasons. In calculating the relative availability of the various forms of nitrogen, a serious difficulty was encountered, namely, the uncertainty as to the standard of comparison. The uniform yield from the parallel plots in previous seasons left little room for the misinterpretation of the results. It was merely necessary in most cases to take the average of the three plots in any one series, and subtracting from that the average yield on the blank plots, the yield due to the manure or fertilizer alone was obtained. Thus, by subtracting the average yield of series 2, the yield due to the 10 grams of sodium nitrate applied on series 8 was obtained. It was necessary to assume, of course, that the amount of nitrogen obtained from the soil itself by the crops on series 8 was equal in amount to the nitrogen obtained from the soil by the crops on series 2, where no nitrogen was applied. As a matter of fact, the average amount of nitrogen withdrawn from the soil itself on series 8 is never equal to, but always greater than, the average amount of nitrogen withdrawn from the soil on series 2. The reason for this is evident, if we consider that the soil nitrogen becomes soluble very gradually, and the thoroughness with which this soluble nitrogen is utilized by the growing crop depends on the root development of

the individual plants. It is quite apparent that the plants on series 2 will grow but slowly, since the amount of nitrogen placed at their disposal is very meagre. In consequence of this limited growth, the root development of the plants will be very limited, and, therefore, not capable of appropriating all or most of the nitrogen rendered soluble in the course of the season. On the other hand, the nitrate nitrogen offered to the plants on series 8 will make possible a good root development and a more thorough exploitation of the nitrogen derived from the soil itself. Moreover, the sodium nitrate will exert a solvent action on the soil humus over and above that exerted by the substances applied on series 2. Thus it will be seen that the average amount of nitrogen credited to the nitrate on series 8 will partly consist of the nitrogen derived from the soil in excess of the average amount derived from the soil of series 2. Since the soil nitrogen becomes soluble but slowly, the amount obtained by the growing crop will be directly proportional to the length of the growing season. Hence it follows that, everything being equal, the amount of nitrogen credited to nitrate will be greater for the long season than it would be for the short season. With these facts in mind, it will be easier to understand the data presented in the following tables, and also to account for apparently striking differences. Meanwhile, it should be added here that soil analyses of our other series, similarly treated, show that the soil of series 8 is actually poorer in nitrogen than is the soil of series 2. The claim of practical people that nitrates often exhaust the soil is thus not without foundation, for it has been shown that, starting with any given soil and cropping it for a series of years with application of nitrate, this soil will contain less nitrogen at the end of that period than a similar soil cropped without any applications of nitrogenous manures whatsoever. While this is in the main true, it does not at all detract from the value of nitrate as a source of nitrogen. Wagner says, with much justice, that such action of nitrate speaks in its favor rather than against it. After all, it is the object of the farmer to sell his soil nitrogen at as profitable a price as he can secure, and it is important that he shall be able to calculate with a reasonahle amount of certainty just how much nitrogen his soil will yield to the growing crop within a given time. The solubility of nitrate renders it immediately available to the crop, and besides, it also helps the farmer to exploit his slowly available capital, the nitrogen of the humus. The modern practice of

gardening. The application was in no case so excessive as to render the condition different from those obtaining in good farm practice, or at the rate of 16 tons per acre.

In the case of nitrogen in artificial forms, the nitrates only were applied in two different quantities, in the one case 5 grams per cylinder, equivalent to 160 pounds per acre, which may be regarded as a medium, and in the second, 10 grams per cylinder, equivalent to 320 pounds per acre, or a large application. This was done in order that the effect of denitrification, if any, might be more fully studied. In the case of ammonia and blood, an amount of nitrogen equivalent to that in the larger quantities of nitrate was used.

The Crops Grown.

The crop grown on the loam soils was wheat, and that was followed by timothy. The conditions under which the first crop was grown were somewhat different than those of the preceding years. The season was longer and included the winter months. Naturally, the temperature, the moisture and the chemical and biological conditions being different, gave rise to results not always concordant with those of the other seasons. In calculating the relative availability of the various forms of nitrogen, a serious difficulty was encountered, namely, the uncertainty as to the standard of comparison. The uniform yield from the parallel plots in previous seasons left little room for the misinterpretation of the results. It was merely necessary in most cases to take the average of the three plots in any one series, and subtracting from that the average yield on the blank plots, the yield due to the manure or fertilizer alone was obtained. Thus, by subtracting the average yield of series 2, the yield due to the 10 grams of sodium nitrate applied on series 8 was obtained. It was necessary to assume, of course, that the amount of nitrogen obtained from the soil itself by the crops on series 8 was equal in amount to the nitrogen obtained from the soil by the crops on series 2, where no nitrogen was applied. As a matter of fact, the average amount of nitrogen withdrawn from the soil itself on series 8 is never *equal to, but always greater* than, the average *amount of nitrogen* withdrawn from the soil on series 2. The reason for this is evident, if we consider that the soil nitrogen becomes soluble very gradually, and the thoroughness with which this soluble nitrogen is utilized by the growing crop depends on the root development of

the individual plants. It is quite apparent that the plants on series 2 will grow but slowly, since the amount of nitrogen placed at their disposal is very meagre. In consequence of this limited growth, the root development of the plants will be very limited, and, therefore, not capable of appropriating all or most of the nitrogen rendered soluble in the course of the season. On the other hand, the nitrate nitrogen offered to the plants on series 8 will make possible a good root development and a more thorough exploitation of the nitrogen derived from the soil itself. Moreover, the sodium *nitrate will exert a solvent action on the soil humus over and above* that exerted by the substances applied on series 2. Thus it will be seen that the average amount of nitrogen credited to the nitrate on series 8 will partly consist of the nitrogen derived from the soil in excess of the average amount derived from the soil of series 2. Since the soil nitrogen becomes soluble but slowly, the amount obtained by the growing crop will be directly proportional to the length of the growing season. Hence it follows that, everything being equal, the amount of nitrogen credited to nitrate will be greater for the long season than it would be for the short season. With these facts in mind, it will be easier to understand the data presented in the following tables, and also to account for apparently striking differences. Meanwhile, it should be added here that soil analyses of our other series, similarly treated, show that the soil of series 8 is actually poorer in nitrogen than is the soil of series 2. The claim of practical people that nitrates often exhaust the soil is thus not without foundation, for it has been shown that, starting with any given soil and cropping it for a series of years with application of nitrate, this soil will contain less nitrogen at the end of that period than a similar soil cropped without any applications of nitrogenous manures whatsoever. While this is in the main true, it does not at all detract from the value of nitrate as a source of nitrogen. Wagner says, with much justice, that such action of nitrate speaks in its favor rather than against it. After all, it is the object of the farmer to sell his soil nitrogen at as profitable a price as he can secure, and it is important that he shall be able to calculate with a reasonable amount of certainty just how much nitrogen his soil will yield to the growing crop within a given time. The solubility of nitrate renders it immediately available to the crop, and besides, it also helps the farmer to exploit his slowly available capital, the nitrogen of the humus. The modern practice of

manuring the crop rather than the soil is amply justified. To be sure, there are other things to be considered. The constant cropping of a soil with applications of nitrogen salts, as the only source of nitrogen, leads to a gradual but steady decrease of the organic portion of the soil. Its physical properties become modified very considerably, and these changes are more often to the disadvantage of the farmer. In experimental work, a factor is introduced which renders it more difficult to interpret the data obtained. However, the farmer has it in his power to employ means which will counteract this tendency and will replace the organic matter removed; and as to the experimenter, he must make proper allowances in calculating his results from the soils variously treated.

In view of the lack of agreement in the parallels from a number of series, it was deemed best to present the data obtained as they are, and to present also the conclusions which our experience suggests as the most plausible under the conditions of the experiment. At the same time, the other side is also presented, so that the persons interested may decide for themselves.

One hundred grains of wheat were planted in each cylinder on October 4th, 1900. One-quarter of the nitrate and of the ammonia was applied in the fall; all of the remaining ammonia on the corresponding cylinders on April 11th, 1901, all of the remaining nitrate on cylinders 7, 9, 11, 13 and 15 on April 11th, and one-half of the remaining nitrate on cylinders 8, 10, 12, 14 and 16 on the same date. On May 2d, 1901, the portions of nitrate still remaining were applied on cylinders 8, 10, 12, 14 and 16. The manures were all applied in the fall in the manner already described. The seed germinated satisfactorily and the plants made good growth. On May 1st a measurement of the plants in the different series was undertaken, and showed that the plants on series 2 were taller and more thrifty than those on series 1; the plants on series 3 and 4 were taller than those on series 5 and 6; little difference was apparent at that time between 7 and 8; the plants in 11 and 12 were taller than those in 9 and 10, and in all four superior to those in 13, 14, 15 and 16; 17 and 18 were about the same, 19 and 20 superior to both, with 20 more advanced than 19. The crop was harvested on July 3d, 1901, and analyzed in the laboratory, the grain and straw being determined separately.

The Results of the Wheat Experiment, 1901.

The accompanying table shows the actual dry matter both in the straw and the grain from each series, the percentage of nitrogen found, the gain in nitrogen due to the materials added, and the percentage of the applied nitrogen recovered. In all cases the net gains in the different series are derived by subtracting the average gain obtained on series 2, upon which minerals only were applied, from the average gain on that particular series.

The application of nitrogen resulted in every case in a gain of dry matter over the series where none was applied. This corresponds with the experience of the other seasons. The average amounts of dry matter and nitrogen from series 1, where nothing was applied, are somewhat less than those from series 2, where minerals only were applied. This indicates that the soil on series 1 is not only poor in available nitrogen, but also deficient in one or more of the mineral constituents. A comparative study of the yields from series 1 and 2 was presented in the report of 1901, and the data presented here can be compared with those already given.

As was already stated, the seasonal conditions for this crop were different from those under which the other crops were grown, and in studying the results obtained these facts should be borne in mind.

TABLE 1.

Results of the Wheat Experiment, 1901.

Series.		Nitrogen applied.	Grain.			Straw.			Total crop.				Per cent. of nitrogen recovered.	Average per cent. of nitrogen recovered. Average of three.	Average per cent. Proximate average.
			Dry matter in crop.	Nitrogen in dry matter.	Nitrogen in crop.	Dry matter in crop.	Nitrogen in dry matter.	Nitrogen in crop.	Dry matter in crop.	Nitrogen in dry matter.	Nitrogen in crop.	Increase over check plot.			
		gms.	gms.	%	gms.	gms.	%	gms.	gms.	%	gms.	gms.			
1	A		35.5	1.727	0.613	55.1	0.402	0.222	90.6	0.922	0.835				
	B		27.8	1.878	0.521	46.4	0.374	0.174	74.2	0.937	0.695				
	C		49.5	1.727	0.855	75.4	0.272	0.205	124.9	0.848	1.060				
2	A		40.2	1.709	0.687	57.3	0.299	0.171	97.5	0.880	0.858				
	B		39.6	1.785	0.707	62.7	0.296	0.186	102.3	0.873	0.893	0.876			
	C		65.8	1.549	1.019	112.4	0.242	0.272	178.2	0.724	*1.291				
3	A	3.95	94.8	1.578	1.496	180.3	0.337	0.608	275.1	0.765	2.104	1.228	31.1		
	B		121.8	1.498	1.818	196.3	0.314	0.616	318.1	0.765	2.434	1.558	39.4	33.3	30.2
	C		99.3	1.506	1.495	171.7	0.315	0.541	271.0	0.751	2.036	1.160	29.4		
4	A	3.99	99.4	1.528	1.519	191.6	0.289	0.554	291.0	0.712	2.073	1.197	30.0		
	B		121.3	1.524	1.849	220.9	0.322	0.711	342.2	0.748	2.560	1.684	42.2	34.0	29.9
	C		101.5	1.504	1.527	187.8	0.286	0.537	289.3	0.713	2.064	1.188	29.8		
5	A	4.02	90.7	1.518	1.377	163.6	0.250	0.409	254.3	0.702	1.786	0.910	22.6		
	B		129.2	1.690	2.183	196.5	0.226	0.444	325.7	0.807	2.627	*1.751	43.6	30.3	23.7
	C		97.4	1.543	1.503	165.3	0.225	0.372	262.7	0.714	1.875	0.999	24.9		
6	A	3.88	87.1	1.547	1.347	143.4	0.241	0.346	230.5	0.734	1.693	0.817	21.1		
	B		76.0	1.659	1.261	118.9	0.258	0.307	194.9	0.805	1.568	0.692	17.8	26.6	19.4
	C		124.7	1.585	1.976	209.3	0.234	0.490	334.0	0.737	2.466	*1.590	41.0		
7	A	0.78	82.1	1.494	1.227	144.5	0.222	0.321	226.6	0.682	1.548	0.672	86.2		
	B		118.3	1.579	1.868	199.6	0.234	0.467	317.9	0.735	2.335	*1.459	187.1	110.9	86.2
	C		69.5	1.518	1.052	118.4	0.242	0.287	187.9	0.713	1.339	0.463	59.4		
8	A	1.55	129.2	1.606	2.077	210.0	0.298	0.626	339.2	0.797	2.703	1.827	117.9		
	B		121.4	1.694	2.057	209.6	0.260	0.545	331.0	0.786	2.602	1.726	111.4	108.9	97.2
	C		119.5	1.597	1.908	197.6	0.240	0.474	317.1	0.751	2.382	1.506	97.2		
9	A	4.73	134.0	1.496	2.005	238.8	0.242	0.578	372.8	0.693	2.583	1.707	36.1		
	B		152.4	1.695	2.583	266.0	0.255	0.678	418.4	0.779	3.261	*2.385	50.4	40.7	40.7
	C		130.0	1.599	2.079	217.4	0.226	0.491	347.4	0.740	2.570	1.694	35.8		
10	A	5.50	154.9	1.550	2.401	257.5	0.250	0.644	412.4	0.738	3.045	2.169	39.4		
	B		196.6	1.866	3.669	297.3	0.274	0.815	493.9	0.908	4.484	*3.608	65.6	51.0	51.0
	C		181.5	1.607	2.917	290.1	0.205	0.605	471.6	0.747	3.522	2.646	48.1		
11	A	4.77	144.6	1.570	2.270	268.8	0.274	0.737	413.4		3.007	2.131	44.7		
	B		190.7	1.764	3.364	300.7	0.264	0.794	491.4		4.158	*3.282	68.8	49.6	40.1
	C		125.0	1.583	1.979	223.0	0.264	0.589	348.0		2.568	1.692	35.5		
12	A	5.54	162.0	1.551	2.513	269.2	0.235	0.633	431.2		3.146	2.270	41.0		
	B		167.9	1.655	2.779	289.2	0.264	0.763	457.1		3.542	2.666	48.1	44.7	44.7
	C		137.7	1.772	2.440	286.6	0.322	0.923	424.3		3.363	2.487	44.9		
13	A	4.80	121.1	1.605	1.944	209.4	0.288	0.603	330.5		2.547	1.671	34.8		
	B		125.8	1.657	2.085	216.4	0.272	0.589	342.2		2.674	1.798	37.5	38.0	38.0
	C		135.4	1.712	2.318	210.0	0.267	0.561	345.4		2.879	2.003	41.7		
14	A	5.57	148.4	1.602	2.377	252.0	0.242	0.614	400.4		2.991	2.115	38.0		
	B		171.0	1.733	2.963	263.4	0.269	0.709	434.4		3.672	2.796	50.2	43.5	43.5
	C		153.9	1.661	2.556	238.0	0.285	0.728	391.9		3.234	2.358	42.3		
15	A	4.66	126.1	1.504	1.897	201.6	0.240	0.484	327.7		2.381	1.505	32.3		
	B		126.8	1.603	2.033	207.4	0.258	0.535	334.2		2.568	1.692	36.3	30.5	30.5
	C		95.6	1.573	1.504	169.1	0.260	0.440	264.7		1.944	1.068	22.9		
16	A	5.43	171.6	1.622	2.783	276.9	0.255	0.706	448.5		3.489	2.613	48.1		
	B		175.3	1.762	3.089	281.7	0.264	0.744	457.0		3.833	2.957	54.5	39.0	39.0
	C		136.5	1.496	2.042	236.1	0.258	0.609	372.6		2.651	*1.775	32.7		
17	A	1.62	108.8	1.615	1.757	189.9	0.252	0.479	298.7		2.236	1.360	84.0		
	B		120.5	1.628	1.962	179.5	0.234	0.420	300.0		2.382	1.506	93.0	77.7	88.5
	C		96.0	1.438	1.380	161.6	0.250	0.404	257.6		1.784	*0.908	56.0		
18	A	1.55	102.8	1.617	1.662	173.3	0.239	0.414	276.1		2.076	1.200	77.4		
	B		94.4	1.692	1.597	145.0	0.249	0.361	239.4		1.958	1.082	69.8	91.4	73.6
	C		166.5	1.517	2.526	125.0	0.254	0.318	291.5		2.844	*1.968	127.0		
19	A	5.64	145.2	1.636	2.375	243.8	0.235	0.573	389.0		2.948	2.072	36.7		
	B		149.5	1.613	2.411	237.0	0.291	0.690	386.5		3.101	2.225	39.4	39.1	39.1
	C		156.3	1.670	2.610	238.9	0.250	0.597	395.2		3.207	2.331	41.3		
20	A	5.37	106.8	[illegible]	1.710	190.7	0.244	0.465	299.5		2.175	1.299	24.2		
	B		192.4	[illegible]	[illegible]	235.4	0.203	0.479	427.8		2.358	1.482	27.6	25.9	25.9
	C		117.6	[illegible]	[illegible]	205.0	0.239	0.492	322.6		2.417	1.541	28.7		

* Not included in the average.

TABLE A.

Average Amount of Dry Matter in Crop, 1901.

Average of Two Marked with an *.

Series.	Grain.	Series.	Straw.	Series.	Proportion of Grain to Straw.
1	81.1 gr.*	1	50.7 gr.*	1	1:1.63
2	99.9 " *	2	60.0 " *	2	1:1.50
3	97.0 " *	3	176.0 " *	3	1:1.81
4	100.4 " *	4	189.7 " *	4	1:1:89
5	94.0 " *	5	164.4 " *	5	1:1.75
6	81 5 " *	6	131.1 " *	6	1:1.61
7	75.7 " *	7	131.4 " *	7	1:1.74
8	123.4 "	8	205 4 "	8	1:1.66
9	132.0 " *	9	228.1 " *	9	1:1.73
10	168.2 " *	10	273.8 " *	10	1:1.63
11	134.8 " *	11	245.9 " *	11	1:1.78
12	155.9 "	12	281.7 "	12	1:1.81
13	127.4 "	13	211.9 "	13	1:1.66
14	151.1 " *	14	245.0 " *	14	1:1.62
15	126.4 " *	15	204.5 " *	15	1:1.62
16	173.4 " *	16	279.3 " *	16	1:1 61
17	114.6 " *	17	184.7 " *	17	1:1.62
18	*98.6 " **	*18*	*159.1 " **	*18*	*1:1.61*
19	150.3 "	19	239.9 "	19	1:1.59
20	120.0 " *	20	205.7 " *	20	1:1.71

Average of Three in Each Case.

Series.	Grain.	Series.	Straw.	Proportion of Grain to Straw.
1	37.6 gr.	1	58.9 gr.	1:1.56
2	48.5 "	2	77.5 "	1:1.59
3	105.3 "	3	182.8 "	1:1.73
4	107.4 "	4	200.1 "	1:1.86
5	105.7 "	5	175.1 "	1:1.65
6	95.9 "	6	157.2 "	1:1.64
7	89.9 "	7	154.2 "	1:1.72
8	123.4 "	8	205.4 "	1:1.66
9	138.8 "	9	241.1 "	1:1.74
10	177.7 "	10	281.6 "	1:1.59
11	153.1 "	11	264 2 "	1:1.72
12	155.9 "	12	281.7 "	1:1.81
13	127.4 "	13	211.9 "	1:1.66
14	157.8 "	14	251.1 "	1:1.59
15	116.2 "	15	192.7 "	1:1.66
16	161.1 "	16	264.9 "	1:1.64
17	108.4 "	17	177.0 "	1:1.63
18	121.2 "	18	147.8 "	1:1.22
19	150.3 "	19	239.9 "	1:1.59
20	116.3 "	20	200.7 "	1:1.81

The figures show that more dry matter, both as grain and straw, were produced on 2 than there was on 1. While more dry matter was produced on 4, where solid and liquid fresh was applied, than there was on 3, where solid fresh alone was applied, there was a greater yield of dry matter, both as grain and straw, on 5, where solid leached was applied, than there was on 6, where solid and liquid leached was applied. Similarly, there was a greater yield of dry matter from series 8, 10, 12, 14 and 16 than there was from the corresponding odd series of 7, 9, 11, 13 and 15. This is as should be expected, for each of the five even series received 5 grams more of sodium nitrate than the preceding odd series. The results are not at all equivocal, and show that where greater absolute amounts of nitrogen were applied, greater absolute amounts of dry matter were harvested, and that without exception. The nitrogen applied in the form of ammonia, both alone or together, with solid leached manure, gave greater returns of dry matter than was produced on the corresponding series, where the nitrogen was applied as dried blood. Similarly, the double quantity of nitrate nitrogen, alone as well as together with solid manure leached, gave greater returns of dry matter than the corresponding, where ammonia nitrogen was used.

The proportion of the grain to the straw seems to be fairly constant. In 3 and 4 there is a wider ratio than in the other cases, indicating that there was some forcing action and more rank growth. It appears, also, that in most cases there is a narrower ratio where the double quantity of nitrate was used as against the single portion. The solid manure fresh shows a narrower ratio than the solid and liquid fresh, when used either with the single or double quantity of nitrate, or when used alone. The solid leached shows a wider ratio than the solid and liquid leached, either when used alone or with the single or double quantity of nitrate. The fresh manures, both solid and solid and liquid, show, with hardly an exception, a wider ratio than the leached manures. In other words, in every pound of dry matter produced on the series where the leached manures were applied, there is more grain than there is in a similar quantity of dry matter obtained from the series where the fresh manures were used. But the absolute quantity of dry matter was greater, on the average, on the series where the fresh manures were used.

TABLE B.

The Average Per Cent. of Nitrogen in the Dry Matter.

Average of Two Marked with an *.

Series.	Grain.	Series.	Straw.	Series.	Total Crop.
1	1.81 %.*	1	.39 %.*	1	.93 %.*
2	1.75 " *	2	.30 " *	2	.83 " *
3	1.54 " *	3	.33 " *	3	.76 " *
4	1.52 " *	4	.29 " *	4	.71 " *
5	1.53 " *	5	.24 " *	5	.71 " *
6	1.59 " *	6	.25 " *	6	.77 " *
7	1.50 " *	7	.23 " *	7	.69 " *
8	1.63 "	8	.27 " *	8	.78 "
9	1.55 " *	9	.23 " *	9	.72 " *
10	1.58 " *	10	.23 " *	10	.75 " *
11	1.58 " *	11	.27 " *	11	.73 " *
12	1.65 "	12	.27 "	12	.77 "
13	1.66 "	13	.28 "	13	.79 "
14	1.63 " *	14	.26 " *	14	.79 " *
15	1.55 " *	15	.25 " *	15	.75 " *
16	1.69 " *	16	.26 " *	16	.81 " *
17	1.62 " *	17	.24 " *	17	.77 " *
18	1.65 " *	18	.24 " *	18	.77 " *
19	1.64 "	19	.26 "	19	.79 "
20	1.58 " *	20	.24 " *	20	.73 " *

The Average Per Cent. of Nitrogen.

Average of Three.

Series.	Grain.	Series.	Straw.	Series.	Total Crop.
1	1.76 %.	1	.34 %.	1	.88 %.
2	1.66 "	2	.27 "	2	.80 "
3	1.52 "	3	.32 "	3	.76 "
4	1.52 "	4	.30 "	4	.73 "
5	1.59 "	5	.23 "	5	.74 "
6	1.59 "	6	.24 "	6	.75 "
7	1.54 "	7	.23 "	7	.71 "
8	1.63 "	8	.27 "	8	.78 "
9	1.60 "	9	.24 "	9	.74 "
10	1.68 "	10	.24 "	10	.80 "
11	1.65 "	11	.27 "	11	.78 "
12	1.65 "	12	.27 "	12	.77 "
13	1.66 "	13	.28 "	13	.79 "
14	1.67 "	14	.27 "	14	.81 "
15	1.56 "	15	.25 "	15	.74 "
16	1.64 "	16	.26 "	16	.78 "
17	1.57 "	17	.24 "	17	.75 "
18	1.59 "	18	.25 "	18	.84 "
19	1.64 "	19	.26 "	19	.79 "
20	1.58 "	20	.23 "	20	.73 "

The above table shows that the dry matter of series 1 is considerably richer in nitrogen than the dry matter from any of the other series, although the *absolute* amount of nitrogen produced from series 1 is very small. Comparing the solid manure fresh, and the solid and liquid fresh, we find that the former has produced dry matter relatively richer in nitrogen than the latter.

In the case of 5 and 6, where solid leached and solid and liquid leached were used respectively, the relation is reversed, the latter showing a proportionately higher content of nitrogen in its dry matter. Series 8, with the double quantity of nitrate, has produced dry matter relatively richer in nitrogen than series 7, where the single portion was used. These relations hold good throughout the even series, 10, 12, 14 and 16, with the double portion of nitrate and the corresponding manures, showing, in practically every case, a proportionately higher content of nitrogen in their dry matter than is true of the odd series, 9, 11, 13 and 15, where the single quantity of nitrate and the corresponding manures were used. These remarks apply to the first of the two tables, where the average of two only was taken in most cases. Nevertheless, they can be applied in a general way, also, to the second table.

TABLE C.

Average Amount of Nitrogen in Crop, 1901.

Average of Two Marked with an *.

Series.	Grain.	Straw.	Total Crop.	Proportion of Grain to Straw.
1	.567 gr.*	.198 gr.*	.765 gr.*	1: .35
2	.697 " *	.178 " *	.875 " *	1: .28
3	1.495 " *	.574 " *	2.070 " *	1: .38
4	1.523 " *	.545 " *	2.068 " *	1: .36
5	1.440 " *	.390 " *	1.830 " *	1: .27
6	1.304 " *	.326 " *	1.630 " *	1: .25
7	1.139 " *	.304 " *	1.443 " *	1: .27
8	2.014 "	.548 "	2.562 "	1: .27
9	2.042 " *	.534 " *	2.576 " *	1: .26
10	2.659 " *	.624 " *	3.283 " *	1: .23
11	2.124 " *	.663 " *	2.787 " *	1: .32
12	2.574 "	.773 "	3.350 "	1: .30
13	2.116 "	.584 "	2.700 "	1: .28
14	2.466 " *	.646 " *	3.112 " *	1: .26
15	1.965 " *	.509 " *	2.474 " *	1: .26
16	2.936 " *	.725 " *	3.661 " *	1: .25
17	1.859 " *	.449 " *	2.309 " *	1: .24
18	1.629 " *	.387 " *	2.017 " *	1: .24
19	2.465 "	.620 "	3.085 "	1: .25
20	1.902 " *	.485 " *	2.387 " *	1: .25

Average Amount of Nitrogen in Crop.

Average of Three.

Series.	Grain.	Straw.	Total Crop.	Proportion of Grain to Straw.
1	.663 gr.	.200 gr.	.853 gr.	1: .32
2	.804 "	.209 "	1.014 "	1: .26
3	1.603 "	.588 "	2.191 "	1: .37
4	1.632 "	.601 "	2.282 "	1: .37
5	1.688 "	.408 "	2.096 "	1: .24
6	1.528 "	.381 "	1.909 "	1: .25
7	1.382 "	.358 "	1.741 "	1: .26
8	2.014 "	.548 "	2.562 "	1: .27
9	2.222 "	.582 "	2.805 "	1: .26
10	2.996 "	.688 "	3.684 "	1: .23
11	2.538 "	.707 "	3.244 "	1: .23
12	2.574 "	.778 "	3.350 "	1: .30
13	2.116 "	.584 "	2.700 "	1: .28
14	2.632 "	.667 "	3.299 "	1: .25
15	1.811 "	.486 "	2.298 "	1: .27
16	2.638 "	.686 "	3.328 "	1: .26
17	1.699 "	.434 "	2.134 "	1: .26
18	1.928 "	.364 "	2.293 "	1: .19
19	2.465 "	.620 "	3.085 "	1: .25
20	1.838 "	.479 "	2.313 "	1: .26

The above tabulations show the average amount of nitrogen in the grain from each series, the average amount of nitrogen in the straw from each series, the average total amount of nitrogen from each series, and the proportion of the nitrogen in the grain and straw of each series. From Table A it can be seen that the yield of dry matter in the straw was greater than the yield of dry matter in the grain. On the other hand, Tables B and C show that both relatively and absolutely a greater amount of nitrogen was obtained in the grain than there was in the straw. While but few grains were produced on series 1, nevertheless, these were well formed. The ratio of grain to straw is somewhat wider here than in most of the other cases, but is not as wide as it is in series 3 and 4. The absolute amount of nitrogen, both in the grain and in the straw, is greater on series 2 than it is on series 1. An explanation of these differences was attempted in the Report for 1901. It is sufficient to state here that the minerals applied on series 2 help to make soluble the inert soil nitrogen, and for this reason the crop on this series finds more nitrogen available than does the crop on series 1, where nothing is applied. Moreover, it is very probable that on series 1 there is lack of one or more of the mineral constituents. The absolute amounts of nitrogen obtained from series 3 and 4 are abont equal, showing that through the longer season of growth the solid manure fresh furnished as much nitrogen as the solid and liquid fresh. However, there was obtained somewhat more nitrogeu in the grain and somewhat less nitrogen in the straw on series 4 than there was on series 3. Series 5 and 6, where the leached manures were applied, gave a smaller yield of nitrogen than the fresh manures on series 3 and 4. The solid manure leached on series 5 gave a greater return of nitrogen, both in the grain and in the straw, than the solid and liquid leached on series 6. As would be expected, there was a greater return of nitrogen from series 8, where 10 grams of sodium nitrate were applied, than there was from series 7, where only 5 grams of sodium nitrate were applied. In series 8, 10, 12, 14 and 16, where 10 grams of sodium nitrate were applied, together with the corresponding manures, there was a greater return of nitrogen than there was from the odd series, 7, 9, 11, 13 and 15, where only 5 grams of sodium nitrate were applied, together with the corresponding manures. In series 9, with the solid manure fresh and 5 grams of sodium nitrate, there was a slightly greater return than there was

from series 11, where the same amount of nitrogen was applied in the form of solid and liquid manure fresh, together with the 5 grams of sodium nitrate. The same is true of 10 and 12, to each of which 10 grams of sodium nitrate were applied, besides the manure, which was solid fresh in 10 and solid and liquid fresh in series 12. This would indicate that more nitrogen was obtained by the crop *from the solid manure alone than there was from the solid and* liquid when applied together. In series 13 a greater amount of nitrogen was returned in the crop than there was on series 15, showing in this case the superiority of the solid leached over the solid and liquid leached. On the other hand, a greater amount of nitrogen was returned from series 16 than there was from series 14, which is in favor of the solid and liquid leached. On the whole, the fresh manures have returned greater amounts of nitrogen in the crop than was returned by the leached manures. This is in accord with previous experience, and shows the greater availability of the fresh manures. The nitrogen in ammonium sulphate made greater returns in the crop, when used either alone or together with solid leached, than was returned by the corresponding series where dried blood was used. *The proportion of the nitrogen in the grain to that in the* straw is, on the whole, rather constant. The fresh manures, where used alone, caused a more rank growth, and as a result there was more straw and more nitrogen in the straw in proportion to the grain on those series. Series 5, 6, 7, 8, 9, 13, 14, 15, 16, 19 and 20 show about the same proportion of nitrogen in grain and straw. In series 11 and 12, with the double quantity of nitrate and the corresponding fresh manures, there was a more rank growth and a wider proportion. In series 9, 17 and 18 the proportion was narrower, particularly in series 9.

THE AVAILABILITY OF THE NITROGEN IN THE SOLID AND IN THE SOLID AND LIQUID MANURE, FRESH.

In determining the availability of the different substances applied, it is necessary, of course, to use a standard of comparison. In these experiments the amount of nitrogen recovered from series 8 is taken as the standard of comparison, with the value of 100, and the amounts recovered from the other soils are measured according to this scale. The interpretation of the data obtained this year presents

greater difficulties than were met with either in 1900 or in 1899; for the conditions of growth were different in 1901. In the first place, the character of the season was different, the seed having been planted in October and the crop harvested in the following July. During the winter a number of cylinders had accumulaed in them masses of ice and snow, which undoubtedly injured the young plants. For this reason it becomes necessary to discard a number of plots whose yields looked suspicious. In Table D are given the amounts recovered from the different cylinders. Column 1 represents the averages of three from each series, column 2 the average from which the suspicious cases have been eliminated, column 3 the calculated recovery according to column 2, and column 4 the per cent. of nitrogen, *not* recovered, also according to column 2. Column 1 is given here in order to enable the reader to judge for himself in how far our dednctions have been warranted.

It will be noticed that unlike the yields of former seasons, the yield from the solid fresh, and the yield from the solid and liquid fresh, on series 3 and 4, respectively, do not differ much. On the other hand, in the other seasons the solid and liquid portion when taken together, showed marked superiority of the solid manure alone.* Thus there was recovered in the wheat 30.2 per cent. from the solid manure fresh, and 29.9 per cent. from the solid and liquid fresh, amounts practically identical. In the oats of 1899, the corresponding figures were 8.3 per cent. and 40.2 per cent., respectively, and in the oat crop of 1900 the corresponding figures were 10.81 per cent. and 30.60 per cent., respectively. This is sufficient to show that through the long season the solid manure fresh was fully as efficacious as the solid and liquid fresh.

THE AVAILABILITY OF THE NITROGEN IN THE SOLID AND IN THE SOLID AND LIQUID, LEACHED.

In former seasons the recovery from the solid manure leached was much less than that from the solid and liquid leached. Thus in 1899 the figures were 8.4 per cent. for the solid leached, and 13.8 per cent. for the solid and liquid leached. In 1900 the figures were 7.38 and 22.06 per cent., respectively. In the wheat crop the

*See N. J. Sta. Rep., 1901, p. 164.

recovery was 23.7 per cent. for the solid leached, and 19.4 per cent. for the solid and liquid leached, showing, if anything, in favor of the solid leached. It will be noticed that the solid fresh proved superior to the solid leached, and the solid and liquid fresh superior to the solid and liquid leached. Also, in this case, the longer season of growth has enabled the crop to obtain a greater proportion of the slowly-available nitrogen contained in the solid portion.

THE RELATIVE AVAILABILITY OF THE NITROGEN IN THE FORM OF NITRATE, AMMONIA AND OF ORGANIC MATTER IN DRIED BLOOD.

As in the other years, the nitrogen in the form of nitrate on series 8 gave a greater return than series 17, where ammonium sulphate was used, and series 18 where dried blood was used. The organic nitrogen in the dried blood made a better showing than in the other seasons. Thus, in 1899 the recovery from the dried blood was 40.4 per cent., and in 1900, 52.15 per cent., as against 73.6 per cent. in 1901. It should be borne in mind, however, that part of the nitrogen, which is here credited to the nitrate, ammonia or dried blood, is really derived from the soil, since with the nitrogen applied the plants on these series were enabled to secure more nitrogen from the soil itself than did the plants on series 2.

THE EFFECT OF THE USE OF THE SOLID AND OF THE SOLID AND LIQUID PORTIONS OF COW MANURE, FRESH AND LEACHED, WITH NITROGEN IN THE FORM OF NITRATE, OF AMMONIA AND OF ORGANIC MATTER.

The object of these combinations was to study the availability of the different nitrogenous substances, when used together, as well as singly. It was, moreover, intended to determine whether the manure would lead to denitrification when applied together with nitrate. As in previous years, the clear manure, free from any admixture of litter, was used, and the amount of manure applied was in no case greater than that applied in actual practice. This season's experience tends to confirm the earlier results in many respects. As in the other cases, the nitrogen in the different combinations showed,

in a number of instances, greater efficiency than where these forms were used singly. The reason for this we must seek in the fact that no single form is so well adapted to nourish the plant continually and uniformly as are the proper combinations. Such uniform feeding not only enables a uniform and healthy growth, but it also makes possible a more thorough utilization of the plant-food made available by providing a better root system. Moreover, the nitrogen salts applied would of themselves help to make soluble the organic matter, while the organic portion would improve the physical condition of the soil. These considerations would explain why, in many instances, the calculated recovery is less than the actual recovery. The influence of the season itself has been discussed elsewhere and need not be considered here.

Th difference between the per cent. of nitrogen actually recovered and the per cent. recoverable, calculated, represents the losses due to all causes; the difference is expressed in percentage in the last column of Table D. The per cent. recovered is greater in every case where the double quantity of nitrate was used with the corresponding manures than is true of the series where the single quantity of nitrate and the corresponding manures were used. The recovery in 9 is about the same as it is in 11, showing no superiority of the solid fresh over the solid and liquid fresh when used together with the single quantity of nitrate. On the other hand, series 10 shows a greater recovery than series 12, and in this case the double quantity of nitrate, when used together with the solid fresh, gave better returns than the double quantity of nitrate used together with the solid and liquid fresh. In the leached manures, where used singly, the solid portion showed a greater recovery than the solid and liquid portion when used together. Similarly, where the leached manures were used together with nitrate, the solid portions gave better returns than the solid and liquid portion. Thus, in series 13 the recovery was 38.0 per cent., as compared with 30.5 per cent. in series 15, and in series 14 it was 43.5 per cent., as against 39.0 per cent. in series 16.

TABLE D.

Wheat—1901.

Series.	Average of Three. %	Nitrogen Recovered. Proximate Average. %	Calculated Recovery. %	Nitrogen not Recovered. %
3	33.3	30.2	......	......
4	34.0	29.9	......	......
5	30.3	23.7	......	......
6	26.6	19.4	......	......
7	110.9	86.2	......	......
8	108.9	97.2	......	......
9	40.7	40.7	39.4	......
10	51.0	51.0	49.1	......
11	49.6	40.1	39.1	......
12	44.7	44.7	48.7	8.3
13	38.0	38.0	33.9	......
14	43.5	43.5	44.1	1.5
15	30.5	30.5	30.6	......
16	39.0	39.0	41.3	5.4
17	77.7	88.5	......	......
18	91.4	73.6	......	......
19	39.1	39.1	39.2	......
20	25.9	25.9	37.6	31.2

The actual recovery exceeds the calculated recovery in four cases out of ten; and namely, in series 9, 10, 11 and 13. The actual recovery is practically the same as the calculated recovery in series 14, 15 and 19. In series 12, 16 and 20 the calculated recovery is greater than the actual recovery, and of these only 20 show a considerable difference. For the sake of comparison, the relative availability of the different substances, as found for the several seasons, are again tabulated here, together with the results for 1901:

	Corn. 1898.	Oats. 1899.	Oats and Millet. 1899.	Oats. 1900.	Oats and Corn. 1900.	Wheat. 1901.
Nitrate of soda	100	100	100	100	100	100
Sulphate of ammonia	99.5	72.9	77.9	99.22	87.75	91.0
Dried blood	95.4	58.5	61.3	68.35	73.07	75.7
Solid manure, fresh	16.76	12.0	43.1	14.16	26.36	31.1
Solid manure, leached	37.87	12.1	46.4	9.67	21.99	24.4
Solid and liquid fresh	49.66	58.2	88.4	40.10	51.46	30.8
Solid and liquid, leached	50.38	20.0	33.0	28.91	35.91	19.9

The relative availability of the nitrogen in the ammonium sulphate and dried blood, while high, does not differ very much from the figures obtained at other times. The relation of the solid to the solid and liquid manures is reversed in 1901, the availability of the first being greater than the availability of the second.

The Experiment with Cabbage, 1901.

This experiment was carried on in cylinders similar to those used in the experiments heretofore described, except that the soil used here was not a heavy loam, as in the other cases, but a sandy loam derived from the former by the addition of an equal portion of sand by weight. These sandy loams are located on the same experiment plot, and they have been treated, as regards manuring and moisture conditions, in the same manner as the others. Their crops were, however, different. On the heavy soils, corn, oats, wheat and timothy were grown, crops adapted to such soils; on the lighter soils, tomatoes, potatoes and sweet potatoes were grown, in order to study these soils in connection with the crops best adapted to them. While the results obtained on the heavier soils have been published yearly since 1899, it was deemed advisable for various reasons to withhold from publication the results obtained on the lighter soils. It was decided to publish the data presented here, together with the results obtained in the analytical study of the different soils, so as to bring out more clearly the mutual relation between the crop and the soil.

The Manures Used.

The several manures employed here were of the following composition:

	Solid, Fresh. %	Solid and Liquid, Fresh. %	Solid, Leached. %	Solid and Liquid, Leached. %
Water	83.488	90.801	81.744	87.614
Ash	2.410	1.734	4.550	2.545
Organic matter	14.102	7.465	13.706	9.841
Nitrogen, total	0.384	0.494	0.416	0.341
" soluble in water	0.048	0.320	0.062	0.122
" as nitrates	....	....	Trace.	....
" as ammonia	0.035	0.046	0.039	0.009
" as soluble organic	0.013	0.274	0.023	0.113
" as insoluble organic	0.336	0.174	0.354	0.219
Phosphoric acid	0.394	0.219	0.433	0.384
Potash	0.224	0.876	0.301	0.597

The manures and fertilizers were applied on August 1st, 1901. The solid fresh contained 4.03 grams of nitrogen and the solid and liquid fresh 4.06 grams of nitrogen, the solid leached 4.01 grams of nitrogen and the solid and liquid leached 3.96 grams of nitrogen. All of the ammonium sulphate and dried blood were applied on the corresponding cylinders, and 5 grams of sodium nitrate each on the corresponding cylinders. On September 2d 5 grams additional of sodium nitrate were applied on 8, 10, 12, 14 and 16, making 10 grams in all for each of these cylinders. Four vigorous plants were set out in each cylinder and made satisfactory progress for a while. It was soon noticed, however, that many of the plants were affected with club-root, and these were pulled up until in some cylinders but one plant remained. It was feared that the experimental results would be strongly vitiated because of this circumstance, but the analytical data showed that the plant-food in the different cylinders was ntilized by the unequal number of plants more evenly than was expected.

The accompanying table shows the dry matter in the different crops, the percentage of nitrogen contained in them, the gain in nitrogen due to the materials added, and the percentage of the applied nitrogen recovered. In all cases the net gains in the different series are derived by subtracting the average gain obtained on series 2, upon which minerals only were applied, from the average gain for that particular series.

TABLE 2.

Results of the Cabbage Experiment, 1901.

SERIES.		Nitrogen applied.	Air-dry matter in crop.	Nitrogen in air-dry matter.	Nitrogen in crop.	Increase over check plot.	Per cent. of nitrogen recovered.	Average per cent. of nitrogen recovered.
		gms.	gms.	%	gms.	gms.		
1	A	....	49.	1.583	0.781	....	....	....
	B	....	72.	1.224	0.879	....	....	....
	C	....	74.	1.247	0.923	....	....	....
2	A	....	67.	1.438	0.963	....	....	....
	B	....	67.	1.263	0.846	*0.896	....	....
	C	....	82.	1.073	0.880	....	....	....
3	A	4.03	98.	1.581	1.549	0.658	16.2	....
	B	....	159.	1.247	1.983	1.087	27.0	21.8
	C	....	100.	1.796	1.796	0.900	22.3	....
4	A	4.06	205.	1.367	2.802	1.906	46.9	....
	B	....	158.	1.454	2.300	1.404	34.6	42.4
	C	....	211.	1.303	2.749	1.855	45.7	....
5	A	4.01	123.	1.462	1.798	0.902	22.5	....
	B	....	138.	1.279	1.765	0.869	21.7	22.0
	C	....	138.	1.279	1.765	0.869	21.7	....
6	A	3.96	139.	1.351	1.878	0.982	24.8	....
	B	....	174.	1.208	2.102	1.206	30.5	28.9
	C	....	174.	1.232	2.144	1.248	31.5	....
7	A	0.78	124.	1.041	1.291	0.395	50.6	....
	B	....	117.	1.128	1.320	0.424	54.4	49.9
	C	....	108.	1.152	1.244	0.348	44.6	....
8	A	1.56	155.	1.096	1.699	0.803	51.8	....
	B	....	138.	1.096	1.512	*0.616	39.7	60.1
	C	....	151.	1.295	1.955	1.059	68.3	....
9	A	4.81	172.	1.430	2.460	1.564	32.5	....
	B	....	210.	1.192	2.503	1.607	33.4	35.0
	C	....	185.	1.502	2.779	1.883	39.1	....
10	A	5.58	159.	1.526	2.426	1.530	27.4	....
	B	....	208.	1.438	2.991	2.095	37.5	32.5
	C	....	105.	1.875	1.969	*1.073	19.2	....
11	A	4.84	159.	1.875	2.981	2.085	43.1	....
	B	....	240.	1.438	3.451	2.555	52.8	51.6
	C	....	258.	1.454	3.751	2.855	59.0	....
12	A	5.61	245.	1.578	3.854	2.958	52.7	....
	B	....	204.	1.668	3.403	2.507	44.7	52.2
	C	....	278.	1.518	4.220	3.324	59.3	....
13	A	4.79	179.	1.232	2.204	1.308	27.3	....
	B	....	145.	1.430	2.074	1.178	24.6	27.3
	C	....	185.	1.271	2.331	1.435	30.0	....
14	A	5.56	167.	1.406	2.348	1.452	26.1	....
	B	....	184.	1.438	2.646	1.750	31.5	28.8
	C	....	190.	1.311	2.491	1.595	28.7	....
15	A	4.74	197.	1.208	2.380	1.484	31.3	....
	B	....	155.	1.335	2.069	1.173	24.7	29.6
	C	....	157.	1.567	2.444	1.548	32.7	....
16	A	5.51	183.	1.422	2.602	1.706	31.0	....
	B	....	192.	1.502	2.884	1.988	36.1	31.6
	C	....	140.	1.732	2.425	1.529	27.8	....
17	A	1.62	135.	1.303	1.759	0.863	53.3	....
	B	....	122.	1.517	1.851	0.955	59.0	57.0
	C	....	147.	1.255	1.845	0.949	58.6	....
18	A	1.55	124.	1.422	1.763	0.867	55.9	....
	B	....	128.	1.367	1.750	0.854	55.1	56.9
	C	....	131.	1.390	1.821	0.925	59.7	....
19	A	5.68	165.	1.470	2.426	1.530	27.2	....
	B	....	185.	1.510	2.841	1.465	25.7	28.9
	C	....	215.	1.238	2.661	1.905	33.6	....
20	A	5.56	150.	1.637	2.456	1.560	28.1	....
	B	....	132.	1.422	1.877	*0.981	17.6	28.7
	C	....	194.	1.446	2.805	1.909	34.3	....

* Not included in the average.

TABLE E.

The Average Amount of Dry Matter in Crop, and the Average Per Cent. of Nitrogen.

Series.	Dry Matter, gr.	Nitrogen, %
1	65	1.31
2	72	1.25
3	119	1.47
4	191	1.36
5	133	1.34
6	162	1.26
7	116	1.11
8	153	1.19
9	189	1.37
10	183	1.47
11	249	1.44
12	242	1.58
13	169	1.30
14	180	1.39
15	169	1.36
16	172	1.53
17	135	1.35
18	128	1.39
19	178	1.47
20	172	1.53

These tabulations show that the results obtained from the lighter soils are similar to those from the heavier soils. It will be noticed that series 1 has produced less dry matter than series 2, but that the relative content of nitrogen is greater than it is in series 2. The solid manure fresh has produced less dry matter than series 4, where the solid and liquid fresh was used, and the solid manure leached, on series 5, has produced less dry matter than series 6, where the solid and liquid fresh was used. On the other hand, the percentage of nitrogen in the dry matter from series 3 is higher than it is in the dry matter from series 4; and the dry matter from series 5 has a higher percentage of nitrogen than the dry matter from series 6. In the even series, 8, 10, 12, 14 and 16, with the double quantity of nitrate, either with manure or without it, there was a greater yield of dry matter than in the corresponding odd series, 7, 9, 11, 13 and 15. The percentage of nitrogen in the dry matter from this even series is also higher in every case than it is in the dry matter from the corresponding odd series. Similarly, the solid and liquid

fresh, having given a greater return of dry matter than the solid fresh, retains the same relation when it is used together with nitrate. Thus, we find that there is a greater yield of dry matter from series 11 than there is from series 9, and a greater yield of dry matter from series 12 than there is from series 10. In series 6, where the solid and liquid leached was used alone, there was a greater return of dry matter than there was from series where the solid leached was used alone. When these are used together with nitrate, the same relations do not hold good, for we find that in series 15 there was no more dry matter produced than there was in series 13, and in series 16 there was even less dry matter produced than there was in series 14. Series 17, where the ammonium sulphate was used, gave a greater return of nitrogen than did series 18, where dried blood was applied. Similarly, in series 19, where the ammonium sulphate was used together with solid manure leached, there was a greater return of dry matter than there was in series 20, where dried blood and solid manure leached were used together. It will also be seen that the fresh manures have produced, on the average, considerably more dry matter than was produced by the leached manures, and the average percentage of nitrogen in the dry matter is also higher in the former than it is in the latter. This fact is perfectly in accord with the accumulated data of several years. The percentage of nitrogen in the dry matter from series 18 is higher than that in the dry matter from series 17, and the same relations hold good in the case of series 19 and 20, respectively.

TABLE F.

The Absolute Amount of Nitrogen in the Dry Matter.

Series.	Nitrogen. gr.	Series.	Nitrogen. gr.
1	.851	11	3.601
2	.896	12	3.826
3	1.776	13	2.203
4	2.617	14	2.495
5	1.776	15	2.298
6	2.041	16	2.638
7	1.285	17	1.818
8	1.827	18	1.778
9	2.581	19	2.523
10	2.706	20	2.630

In considering the nitrogen yield in the crop from the different series, we find that there was a greater absolute amount of nitrogen contained in the dry matter from series 2 than there was in that from series 1. The solid and liquid manure fresh gave a greater return than did the solid fresh; and the solid and liquid leached gave a greater return than did the solid leached. The same relations hold good, also, in the combinations, for we find that series 11 gave a greater return than series 9, and series 12 gave a greater return than series 10. Similarly, series 15 gave a somewhat greater return than series 13, and series 16 gave a greater return than did series 14. It will be seen, therefore, that while these relations hold good, the superiority of the solid and liquid fresh over the solid fresh is even greater in combination than when they are used alone; on the other hand, the superiority of the solid and liquid leached over the solid leached is less pronounced in the combinations than it is when they are used alone. In every case there was a greater return of nitrogen in the even series, 10, 12, 14 and 16, than there was from the corresponding odd series, 7, 11, 13 and 15. Series 17 gave a greater return than did series 18; on the other hand, series 20 gave a greater return than did series 19.

THE AVAILABILITY OF THE NITROGEN IN THE SOLID AND IN THE SOLID AND LIQUID PORTIONS OF THE FRESH AND LEACHED MANURES.

Table G shows that the recovery from the solid and liquid fresh was greater in every case than the recovery from the solid fresh, a fact perfectly in accord with previous experience. Similarly, the recovery from the solid and liquid leached was greater than that from the solid leached. In this case, however, the differences are not as great as they are in the case of the solid manure. Thus, we find that there was a recovery of 42.4 per cent. in the solid and liquid fresh, as against a recovery of 21.8 per cent. in the solid fresh. In the leached manures the recovery was 28.9 per cent. in the solid and liquid portion, as against 22 per cent. in the solid portion. Also, this agrees with the results of other years, and is as should be expected, for the solid and liquid leached does not contain as much soluble nitrogen as is contained in the solid and liquid fresh. It appears, also, that the recovery from the solid leached is

practically the same as the recovery from the solid fresh, and the recovery from the solid and liquid leached is not much greater than the recovery from the solid fresh.

THE RELATIVE AVAILABILITY OF THE NITROGEN IN THE FORM OF NITRATE, AMMONIA AND OF ORGANIC MATTER IN DRIED BLOOD.

The recovery from the nitrate, both where the single and the double portions were used, is smaller than usual. In series 7 only 49.9 per cent. of the amount applied was recovered, and in series 8 only 60 per cent. The recovery from the ammonium sulphate and from the dried blood was proportionately greater than that from series 7 alone, or of the average of series 7 and 8. This, naturally, makes the availability of the ammonia and dried blood nitrogen, as measured in terms of nitrate nitrogen, comparatively high. As to the recovery from the ammonia nitrogen itself, it is practically the same as that from the dried blood, the two being 57 per cent. and 56.9 per cent., respectively.

THE EFFECT OF THE USE OF THE SOLID AND OF THE SOLID AND LIQUID PORTIONS OF COW MANURE, FRESH AND LEACHED, WITH NITROGEN IN THE FORM OF NITRATE, OF AMMONIA AND OF ORGANIC MATTER.

The recovery from the combinations of the different materials is, in four cases out of the ten, greater than the calculated recovery; in four cases it is less than the calculated recovery, and in two cases the calculated and the actual recovery are practically the same. The recovery from 11 and 12, where the solid and liquid fresh was used together with nitrate, is 51.6 and 52.2 per cent., respectively, and exceeds in both cases the calculated recovery. The recovery in 9 and 10 is 35 and 32.5 per cent., respectively, and exceeds the recovery from either the solid leached or the solid and liquid leached. The recovery from 19 is less than that from 20, and in the latter it is not much different from the calculated recovery. With the exception of series 10, the recovery from the manures, both fresh and leached, is greater when used together with the double

portion of nitrate than when used with the single portion. The accompanying table shows the average percentage recovery of nitrogen when the materials furnishing it were used singly as well as when they were used in combination, together with the percentage increase of nitrogen from combinations of two materials, calculated from the increase obtained when they were used singly.

TABLE G.

	No. of Series.	Nitrogen Recovered. %	Calculated Recovery. %	Nitrogen not Recovered in the Combinations of Materials. %
Solid manure, fresh	3	21.8	....	....
Solid and liquid, fresh	4	42.4	....	....
Solid manure, leached	5	22.0	....	....
Solid and liquid, leached	6	28.9	....	....
Sodium nitrate	7	49.9	....	....
Sodium nitrate	8	60.1	....	....
Ammonium sulphate	17	57.0	....	....
Dried blood	18	56.9	....	....
7 and 3 in	9	35.0	26.88	....
8 and 3 in	10	32.5	32.45	....
7 and 4 in	11	51.6	43.61	....
8 and 4 in	12	52.2	47.29	....
7 and 5 in	13	27.3	26.47	....
8 and 5 in	14	28.8	32.57	11.57
7 and 6 in	15	29.6	32.36	8.53
8 and 6 in	16	31.6	37.67	18.39
17 and 5 in	19	28.9	32.01	9.71
18 and 5 in	20	31.2	31.69	1.6

The Availability of the Nitrogen in the Several Nitrogenous *Materials*.

Nitrate of soda	100
Sulphate of ammonia	94.8
Dried blood	94.7
Solid manure, fresh	36.3
Solid manure, leached	36.6
Solid and liquid, fresh	70.5
Solid and liquid, leached	48.1

These figures show that the availability of the nitrate nitrogen is greater than that of the ammonia and of the organic nitrogen in dried blod. They show that the availability of the nitrogen in the solid and liquid fresh is greater than that in the other forms of manure. They show that the availability of the nitrogen in the

solid and liquid manure leached is greater than that in either the solid fresh or the solid leached. They show that the availability of the nitrogen in the ammonia or dried blood is greater than that of the nitrogen in any of the manures. These facts have been found to be so, with but few exceptions, in the other experiments.

Changes in the Nitrogen Content of the Sandy Soils.

The study of the relative value of different nitrogenous substances has been carried on in two different soils, a shale loam and a lighter sandy loam. The derivation of these soils and their treatment have been discussed in previous reports, and it is unnecessary to consider the details here. It became expedient as the work progressed to determine in how far the soil nitrogen influenced the utilization of the manure or fertilizer nitrogen, and in how far it affected the interpretation of the results obtained. The amount of nitrogen in each cylinder was very considerable at the beginning of the experiments. In the heavier soils there was contained in each case 175 to 180 grams of nitrogen in the surface portion; in the lighter soils, derived from the first by the addition to it of an equal quantity by weight of quartz sand, there was probably contained 88 to 90 grams of nitrogen in each case at the beginning of the experiments.

The exact determination of the nitrogen in these soils presents great difficulties. Notwithstanding the greatest care in the analytical part of the work it is yet impossible to reduce the limit of error to a small fraction of one gram. This is largely due to the comparatively great amount of soil to be dealt with. Only a limited quantity of soil can be taken for the determination of nitrogen, and the least error is, therefore, mnltiplied enormously.

By comparing the amount of nitrogen originally present in the soil with the amount left there after a series of crops had been removed from it (taking into consideration, of course, the amounts of nitrogen applied and removed in the crops during that time), it becomes possible to determine the part played by the soil nitrogen in these experiments. In calculating the yields from the several series it was assumed that the amount of nitrogen derived in each case from the soil itself was the same and equal to that removed by the crop from series 2, where no nitrogen was applied. Thus, in series 7, for instance, the yield of nitrogen in the crop was due in

part to the nitrate applied and in part to the soil itself. By subtracting from the total yield the amount found in the crop on series 2, the quantity of nitrogen due to the nitrate alone is found. Naturally, the question arose whether the amount of nitrogen removed from the soil itself was the same in each case. This question could only be answered by the analysis of the soil. But even the soil analysis does not give an absolutely correct answer to this question. Apart from the uncertainty due to the analytical work itself, there are other factors to be considered. As to the former, it is mainly due to the large quantity of soil dealt with, and in these experiments does not exceed one gram on the total quantity of nitrogen found, in most cases amounting to rather less than one-half gram. This error, then, while fairly large, still allows a close approximation to the actual amounts of nitrogen present in the soil. The exact influence of the other factors mentioned above cannot always be determined. Their *possible* influence will become evident from the following considerations: The inert soil nitrogen contained in the organic portion of the soil is changed slowly. There is no doubt that the mineral portion of the soil exerts a great influence on this solution, and since the mineral salts contained in the several series are not exactly alike because of the different treatment, their solvent action on the organic portion of the soil is variable. Where the mineral salts were applied together with manure, the relations are still more complicated. In the first place, there occur in the soil various processes of decay, during which some of the nitrogen is undoubtedly set free in the gaseous form, part of it as ammonia and part of it as elementary nitrogen. In the second place, there is a possibility, at least, that some of the nitrate, either derived from the soil or applied as such, is denitrified when in contact with large quantities of organic matter. In the third place, there exist in the soil a number of organisms capable, under certain conditions, of fixing atmospheric nitrogen. Moreover, some part, at least, is played by the nitrogen brought down to the soil in atmospheric precipitation. Considering this at five pounds per acre, annually, there would be brought down on the three square feet of surface in each cylinder, in five years, about 3 grams of soluble nitrogen. And, finally, the soluble nitrates are, in part, washed into the subsoil beyond the reach of the plants. It will be seen, thus, that the analytical results show only the algebraic sum of these various influences. It is also evident that the relative influence of each of these factors is not the

same in the several series. The amount of nitrogen lost from the soil by decay will depend on the kind and number of bacteria present in the soil, and these will be determined by the conditions of moisture, temperature and reaction of the soil, as well as by its content of soluble salts. Since these conditions vary in the several series, the extent of change and the amount of nitrogen set free in this change are also variable. The addition to the soil of manure will modify its temperature and moisture conditions, hence these will not be the same in series 7 as they are in series 12, for instance. Moreover, together with the manure, there are introduced into the soil great numbers of different bacteria, which will also affect the condition of the soil nitrogen. It is well known that in the nitrification of organic or ammonia nitrogen a portion of it is set free. The extent of the loss is quite variable. In the nitrification of ammonia salts it is slight; in the nitrification of organic matter it is greater, mainly because the process in the latter case is more complex. The extent of denitrification in the soil will largely depend on the amount of organic matter added to it in the manure. It is the purpose of the cylinder experiments to determine, among other things, whether denitrification really does take place in the soil when only ordinary quantities of manure are applied. As will be shown later, both the crop analyses and the soil analyses show that there was no denitrification. As to the fixation of atmospheric nitrogen by bacteria in the cylinder soils, it is difficult to determine at present. There are one or two instances which make it appear that there was some fixation there. It was already stated that the amount of nitrogen found in the soil represents the algebraic sum of the different gains and losses, viz., the manures and fertilizers applied, the atmospheric precipitation, the possible addition from the subsoil, the fixation of atmospheric nitrogen by bacteria, removal of nitrogen by crops, denitrification, various processes of decay, leaching action of rain, etc. All these factors make it difficult to determine with certainty whether any fixation does take place, unless such fixation is very considerable.

In the spring of 1902 the soil from the three cylinders in each series was removed, placed in one pile and thoroughly mixed. A representative sample was then taken, the soil divided into three equal portions and returned to the respective cylinders. The samples were then taken to the laboratory and air-dried, showing the following results:

Weight of Moist and Air-Dry Soil.

Series.	Fresh Sample. gr.	Air-Dry Sample. gr.	Loss %
1	307.95	278.05	9.71
2	287.20	258.05	10.15
3	267.70	238.20	11.02
4	266.30	238.75	10.35
5	252.90	225.45	10.86
6	271.50	242.05	10.85
7	273.10	245.55	10.09
8	264.70	238.15	10.03
9	264.10	235.35	10.89
10	262.60	233.65	11.03
11	280.20	250.30	10.61
12	264.50	234.95	11.18
13	253.00	225.30	11.16
14	251.70	223.35	11.31
15	254.80	225.80	11.48
16	272.95	242.00	11.34
17	252.55	226.25	10.42
18	254.75	226.90	10.93
19	264.00	233.20	11.67
20	262.70	234.85	10.61

The above table shows that the samples taken under the same conditions from the several series contained varying amounts of moisture. The losses indicate the water-holding power of the different soils. Theoretically, the soils containing the greater amount of organic matter would also possess a greater water-holding power. The facts in this case are mostly in accord with theory. Thus, on series 1, 2, 7 and 8, *where no manures were applied, the humus content of the* soil was reduced by successive crops, and with it its water-holding power, for less moisture was held in the samples from these series than from any of the others. The average amount of moisture lost from these series on air-drying was 9.99 per cent., while the average lost from the other sixteen series was 10.98; in other words, a difference of 1 per cent. In series 9, 10, 11, 12, 13, 14, 15 and 16, where manure and nitrate were applied together, the average loss was greater than it was on series 3, 4, 5 and 6, where the manures were used alone, the figures being 11.12 per cent. and 10.77 per cent., respectively. The loss from series 3 was greater than that from series 4, while in series 5 and 6 the losses were about the same. The losses from the even series, 10, 12, 14 and 16, where the double quantity of nitrate was used, are, with but one exception, greater than those from the corresponding odd series, 9, 11, 13 and 15, where the half

portion of nitrate was used. This would indicate that the water-holding power of the soil in the even series was greater than that of the soil in the odd series. The loss from series 18, where dried blood was used as the source of nitrogen, is greater than that from series 17, where ammonium sulphate was used, showing that the water-holding power of the soil in series 18 was greater than that in series 17. On the other hand, the loss from series 19 was much greater than that from series 20; in fact, greater than it was in any other series. Taken together with the fact that the nitrogen content of this soil, as well as the loss on ignition, is greater in this soil than in any other, it becomes evident that, everything being equal, the water-holding power of any soil is greater or less as its content of organic matter is greater or less. It still remains to be explained, however, why there is more organic matter and more nitrogen in series 19 than there is in any of the other series. There is a possibility, at least, that certain species of nitrogen fixing bacteria have found a congenial medium in that soil, and have enriched it at the expense of the atmospheric nitrogen. Such an assumption, however, would take us into the realm of mere speculation, and it is best to let the facts stand as they are for the present.

Hygroscopic Moisture, Total Moisture, and Volatile Matter in the Cylinder Soils.

Series.	Hygroscopic Moisture. %	Loss on Ignition. %	Loss on Ignition. Less Hygroscopic Moisture. %	Total Moisture. %
1	1.01	4.41	3.40	10.72
2	.97	4.14	3.17	11.12
3	1.00	4.47	3.47	12.02
4	.97	4.27	3.30	11.32
5	1.00	4.29	3.29	11.86
6	.88	4.17	3.29	11.73
7	.93	3.98	3.05	11.02
8	.75	3.71	2.96	10.78
9	.78	4.42	3.64	11.67
10	.84	4.08	3.24	11.87
11	.80	3.99	3.19	11.41
12	.82	4.44	3.62	12.00
13	.90	4.48	3.58	12.06
14	.87	4.48	3.61	12.18
15	.86	4.47	3.61	12.34
16	.93	4.49	3.56	12.27
17	.86	4.30	3.44	11.28
18	.81	4.46	3.65	11.74
19	.98	4.93	3.09	12.65

The figures presented in the above table bring out some interesting relations of the volatile matter to the hygroscopic moisture. It will be noticed that the loss on ignition is greater in 1 than it is in series 2, and, similarly, the content of hygroscopic moisture in series 1 is greater than it is in series 2. The loss on ignition is greater in series 3 then it is in series 4, and, similarly, the content of hygroscopic moisture is greater in series 3 than it is in series 4. The same is true of series 7 and 8 and of series 12 and 11. The loss on ignition in 5 is equal to that in 6, but the hygroscopic moisture is greater in 5 than it is in 6. The loss on ignition in series 7 and 8 is very low, indicating that the amount of organic matter present there is smaller than it is in the other series. In series 8 the hygroscopic moisture is also lower than in any other series. The average loss on ignition from series 13, 14, 15 and 16, where the leached manures were used, is greater than that from series 9, 10, 11 and 12, where the fresh manures were used; this is largely due to the low content of volatile matter in series 10 and 11. Barring series 7 and 8, the lowest content of volatile matter is found in series 2, which is in agreement with other facts. There is a greater loss on ignition from series 18 than there is from series 17; on the other hand, the loss on ignition from 19 is greater than it is from 20, and, moreover, the loss from 19 is greater than that from any other series. This fact will be considered again later on. Comparing the total moisture content in the several series, we find that it is greater in series 2 than it is in series 1, and greater in 3 and 5 than it is in 4 and 6, respectively. The total content of moisture is greater in 7 than it is in 8; but, when these are used in combination, we find that in most cases the water-holding power of the soils where the double quantity of nitrates was used was greater than that in the corresponding series, where the single quantity of nitrate was used. Thus, it is greater in 10, 12 and 14 than it is in 9, 11 and 13, respectively. Similarly, the total moisture was greater in 18 than it was in 17, although the reverse is true of 19 and 20. It has been pointed out already that for some reason the content of organic matter and of nitrogen are abnormally high in series 19. Since the water-holding power of a soil is determined in a measure by its content of organic matter, it becomes clear why the total moisture, as well as the hygroscopic moisture, are higher in series 19 than they are in any other series. It will also be observed that the total moisture is greater in series 13, 14, 15 and 16, where the leached manures were used, than it is in series 9, 10, 11 and 12, where the fresh manures were used.

The Income and Outgo of Nitrogen in the Different Series.

The *sandy loam soils considered here were made up of the shale* soil used in other series and of quartz sand, one part by weight being taken of each. The former was obtained from a vacant lot near the Experiment Station building. So far as is known, this soil was never under cultivation, and it is quite certain that no crops had been grown upon it for twenty years or more. On analysis, this wild soil proved to be very rich in nitrogen. The quartz sand, presumably, contained no nitrogen, although it is quite likely that it contained small amounts of it. It was not thought at the time the cylinder experiments were started that the sand would be required for analytical examination, and no sample of it was, therefore, preserved. Hence the possible content of nitrogen in the sand itself is disregarded here, and the calculations made on the basis of the shale soil alone, one-half *of the total weight of the soil in each cylinder being regarded* as sand. When the cylinder experiments were begun in 1898, and the soils weighed off, equal quantities were presumably taken for the several cylinders. On sampling the soils for analysis in the spring of 1902, the soils from the three cylinders in each series were mixed, weighed in mass and exactly one-third returned to each cylinder. These second weighings, when calculated to the water-free basis, showed, however, that the absolute amounts were not the same in each case, and for this reason it became necessary to allow for the difference in calculating the total amount of nitrogen contained in each series and each cylinder. The following are the amounts of water-free soil found in each series, the figures in each case representing one-third of the total weight of soil in the series:

Amounts of Water-Free Soil per Cylinder.

Series.	Grams.	Series.	Grams.
1	87.985	11	88.384
2	87.154	12	87.848
3	89.507	13	86.192
4	90.053	14	87.259
5	87.924	15	85.916
6	88.052	16	87.168
7	89.304	17	88.157
8	90.667	18	88.095
9	88.562	19	87.187
10	87.215	20	87.564

The following table gives the average amount of the nitrogen in each series, the total amount applied from 1898 until the spring of 1902, the amount removed in the crops during that time, the amount present as found by analysis and the amount not accounted for, representing the loss from all causes. It will be noticed that in every series, without exception, there was a loss of nitrogen, the minimum being 13.10 grams in series 18 and the maximum 26.89 grams, or almost double the least loss in series 4. This does not take into account the amounts of soluble nitrogen probably added to the several cylinders in atmospheric precipitation, and which may have amounted to two or three grams per cylinders for the four years. The data presented here remind us again quite forcibly that there is an enormous loss of nitrogen from out arable soils, a loss that is bound to be felt sooner or later unless the proper means are taken to retard such losses. Our investigations have not as yet proceeded far enough to show us what proportion of the loss is due to the draining away of the dissolved nitrogen from the soil and what proportion of it is due to the liberation of elementary nitrogen in the various processes of decay. But the indisputable fact is that very considerable losses do occur. In series 4, for instance, this loss is more than 29 per cent. of the amount originally present, and the average loss is more than 20 per cent. or one-fifth of the amount originally present. These losses, as the table shows, are fairly uniform, although apparently inexplicable differences occur. In series 1 the loss was somewhat greater than in series 2, due probably to the fact that the growth on series 1 was always slight and not capable of exploiting much of the soil nitrogen as it became available. This reasoning need not necessarily apply to series 7 and 8 or to series 17 and 18, for on these the plant development, though differing in extent, was always normal. The loss from series 4, where solid and liquid manure fresh was applied, is greater than that from series 3, where solid fresh was used. That seems reasonable enough, since a considerable portion of the manure on series 4 was applied in the soluble and easily decomposed form. More strange is the fact that the loss from series 3 is practically the same as that from series 1. This means either that there was very little loss from the manure itself or that the manure diminished the loss of the soil nitrogen. In the leached manures, the loss from series 6, where the solid and liquid portions were used together, is greater than that from series 5, where the solid leached was used alone, but the difference, as would be expected, is not as great here as it is between the fresh manures.

Amount of Nitrogen Present in the Soil.

The losses from the other series will be considered in the discussion of the effectiveness of the different combinations. In this place attention is called to the content of nitrogen in the different series. It was stated elsewhere that where nitrate alone was used the plants were enabled to obtain a greater amount of nitrogen from the soil itself than the plants on series 2, where no nitrogen was applied, and where the plants were, therefore, less vigorous. Similarly, since the crops in series 2 removed more nitrogen than those of series 1, the soil of the former should contain less nitrogen than the soil of the latter. As to series 1 and 2, we find this to be the case, but in series 7 and 8 *there is apparently more nitrogen than in series 2.* The difference is only seeming, however, for series 7 and 8 contain more soil than series 2. There is no doubt that a greater part of the soil nitrogen, which drained away as it became soluble, was captured by the plants of series 7 and 8 than there was captured on series 2. Some of this nitrogen was again made insoluble and left in the soil as roots and stubble, a proportionately greater amount being left on 7 and 8 than there was on 2, and hence the analytical data do not show differences as they really are. The soil in series 3 contains more nitrogen than that in series 4, and the soil in series 5 a slightly greater quantity than the soil in series 6. It also appears that in the even series, 10, 12, 14 and 16 (with but one exception), the amounts of nitrogen present in the soil are greater than in the odd series, 9, 11, 13 and 15, where the single quantity of nitrate was used with the respective manures. There is, on the average, more nitrogen in the soils of series 13, 14, 15 and 16, where the leached manures were used in combination with nitrate, than there is in the series 9, 11, 13 and 15, where the fresh manures were used in combination with nitrate. With but one exception, there is more nitrogen present in the soils where the solid manures were used in combination with nitrate than there is in the soils where the solid and liquid manures were used in combination with nitrate. More nitrogen is present in series 18 than there is in series 17, although there was more of it *applied to, and less removed from, the latter.* In series 19 there is more nitrogen present than in any other series, yet the reason for this is not yet clear. It is possible that the sulphuric acid derived from the ammonium sulphate (the latter being nitrified) diminished the loss of the ammonia formed from the humus of the soil and from

the manure; or it may be that there was fixation of atmospheric nitrogen in series 19, where the nitrogen fixing bacteria have found more favorable conditions for their development.

Nitrogen in Sandy Loam.

Cylinder Soils.

Series.	Nitrogen Originally Present. gr.	Applied, gr.	Removed. gr.	Present, gr.	Loss. gr.
1	89.73	......	8.199	62.27	19.26
2	88.85	......	9.807	60.27	18.77
3	91.24	20.19	16.746	75.32	19.36
4	91.80	22.68	16.545	71.04	26.89
5	89.65	18.07	13.281	72.77	21.67
6	89.77	20.56	15.058	72.43	22.84
7	91.04	3.92	11.687	62.38	20.89
8	92.43	7.80	14.602	61.80	23.83
9	90.29	24.11	17.047	72.54	24.81
10	88.94	27.99	18.065	79.41	19.46
11	90.09	26.60	21.629	73.62	21.34
12	88.76	30.48	21.322	76.43	21.49
13	87.88	21.99	15.649	77.20	17.02
14	88.97	25.87	18.293	78.30	18.25
15	87.58	24.48	18.745	76.81	16.51
16	88.86	28.56	19.432	75.13	22.66
17	89.87	8.03	12.849	67.91	17.14
18	89.82	7.55	15.891	66.38	13.10
16	88.89	26.10	16.077	82.80	16.11
20	89.27	25.62	14.446	76.79	23.65

The following table shows the effectiveness of the different combinations from the soil standpoint. The calculated loss was obtained in each case by taking the sum of the losses that occurred where the materials were used singly. Thus the calculated loss in series 9 represents the loss in series 3, less the loss on series 2 (check plot), plus the loss in series 7, less the loss in series 2. The actual loss was obtained in each case by subtracting from the sum of the initial and the applied nitrogen the amount removed in the crops, as well as that found to be still present in the soil. The figures show that in most cases there was a slighter loss than the calculated, and they prove that there was apparently no denitrification in any of the series where the nitrate was used together with manure. In series 9 and 20 there was a loss over the amount calculated. In these the loss

could hardly be due to denitrification, surely not in 20, for no nitrate was used here. As to series 9, if the loss was due to denitrification there should have been a still greater loss in series 10, where the same manure was used with the double quantity of nitrate. It seems, on the contrary, that in almost every case there was a greater gain over the calculated in the series where the double quantity of nitrate was used, as against the corresponding series, where only the single quantity of nitrate was used.

Losses of Nitrogen from the Soils.

Series.	Calculated Loss. gr.	Actual Loss. gr.	Gain or Loss over Calculated. gr.
9	2.71	6.04	— 3.33
10	5.65	.69	+ 4.96
11	10.14	2.57	+ 7.56
12	13.08	2.72	+10.36
13	5.02	+1.75	+ 6.77
14	7.96	+0.52	+ 8.48
15	6.19	+2.26	+ 8.45
16	9.13	3.89	+ 5.24
19	1.27	+2.66	+ 3.93
20	+2.77	4.88	— 7.65

REPORT OF THE ASSISTANT IN SOIL CHEMISTRY AND BACTERIOLOGY.

SOIL CHEMISTRY AND BACTERIOLOGY.

Contributions to the Morphology and the Physiology of Denitrification.

Saprophytic organisms, whether molds or bacteria, utilizing for their development dead organic tissue, cause in the latter more or less deep-seated changes. These changes frequently lead to very considerable losses of nitrogen, whose extent is determined by the character of the decaying substance, by the organisms present and by the conditions under which the decomposition takes place. Realizing the great importance of such processes to agriculture, many investigators have occupied themselves with the subject, endeavoring to make clear the nature of decay, both in the presence and in the absence of oxygen, and to suggest measures whereby the losses of nitrogen may be reduced to a minimum. The greatest difficulty encountered in these investigations is the uncertainty of one factor—the organisms in the substance undergoing decay. For it happens that the least change in the conditions of the experiment disturbs the established equilibrium, new species come to the foreground, new physiological activities become prominent, new products are formed and new reactions take place. In this case it is assumed, of course, that the decomposition is taking place under natural conditions, where the contamination from the surroundings is not excluded. But, in order to understand the processes of decay in their simplest form, it becomes necessary to study the physiological activities of single species in pure culture, for only in this way can the problem be reduced to terms which are sufficiently exact. The data thus secured can be utilized with great advantage in the examination of the complex problems where mixtures of bacteria are dealt with, and where secondary reactions play an important part.

When large quantities of organic matter decay in the presence of nitrates, the latter are deoxidized, and the reduction may be carried on far enough to lead to the evolution of free nitrogen. The true

significance of the partial or complete deoxidation of nitrate in agriculture, as gauged by the present-day knowledge, will be discussed elsewhere. But in this place it should be noted that enormous quantities of nitrogen are lost in the various processes of decay, even when nitrates are absent. Losses of nitrogen occur from the manure in the stable and from the manure heap, and losses also occur from that manure after it is placed in the soil. Of the nitrogen contained in the fresh manure but a small proportion is required in the crops, and it is doubtful whether, on the average, more than 25 per cent. are recovered.[1] With a better understanding of the processes of decay, much could be done to diminish such losses. Even if the utilization of the manure-nitrogen should be increased 10 per cent., the gains to agriculture would be great. It is quite evident that the losses of nitrogen are greater where there is a proportionately greater amount of it in soluble compounds. Thus in the decomposition of liquid manure, its soluble nitrogen compounds, whether urea or hippuric acid, are readily broken down and ammonia liberated. The reactions may be represented as follows:

$$CO\left\{\begin{matrix}NH_2\\NH_2\end{matrix}\right. + H_2O = CO_2 + 2NH_3.$$

Urea.

or, $CO_2\,H\,CH_2 - NH\,CO\,C_6H_5 + H_2O = CH_2 - NH_2\,COOH + C_6H_5\,COOH$.

Hippuric acid. Glycocol. Benzoic acid.

and $CH_2\,NH_2\,COOH + H_2O = CH_2\,OH\,COOH + NH_3$.

These reactions represent a type of ammoniacal fermentation which is quite common, leading to the volatilization of ammonia by the changes in the amido-compounds. At the same time the nitrogen from decaying organic substances may be set free in its elementary state, although it is still a disputed point as to what extent the latter takes place. There are a number of experiments carefully planned and carefully carried out which seem to prove that no nitrogen is set free as such from decaying nitrogenous substances, and there are experiments seemingly accurate which indicate that such losses do occur. It should be borne in mind, however, that the character of decompostion is determined by the supply of oxygen. With a plenti-

[1] See Wagner & Dorsch, Die Stickstoffdüngung der landwirtschaftlichen Kulturpflanzen, p. 247. E. B. Voorhees, New Jersey Sta. Rep 1901, p. 179. Adolf Mayer, Agriculturchemie, II. vol., part 2, 5th edition, p. 51. Wollny, Die Zersetzung der organischen Stoffe, p. 407.

ful supply of the later, oxidizing processes prevail, and the ammonia is gradually oxidized to nitrates and nitrites. Where the supply of oxygen is cut off, or is limited, the reducing processes prevail—there is only a partial decomposition of the substance, with scarcely any loss of nitrogen. The first type of decomposition is called *decay*, the second, *putrefaction*. However, it is not always easy to draw the line of demarcation, especially where large quantities of organic material are undergoing decay. As to putrefaction, the preponderance of opinion is that no appreciable loss of gaseous nitrogen takes place here. Immendorff[1] supports this view, and quotes Kellner,[2] Tacke,[3] Ehrenberg[4] and Schlösing,[5] to the same effect. Similar conclusions are reached by Müntz and Girard (Ann. Agron. 19, 1893, pp. 5–49), Schneidewind,[6] Dietzell[7] and Pfeiffer.[8] Dietzell finds from his experiments that "the loss of nitrogen and of organic substance is avoided when no aeration can take place. On the other hand, there is some evidence to show that free nitrogen is evolved in processes of putrefaction.

Wollny[9] cites König and Kiesow,[10] Dietzell,[11] Morgen and König,[12] as supporting this view, but, on summing up the evidence, he concludes that "no free nitrogen is split off in the putretative decomposition of organic substances."

Conditions are quite different in decay proper. The different investigators are not unanimous on the subject, and it will be seen below how the apparent discrepancies may be accounted for. Careful measurement and analysis of the gases evolved lead Ehrenberg[13] to decide that no elementary nitrogen is liberated in decay, when there is a plentiful supply of oxygen. Opposed to this are the re-

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[1] Landw. Jahrb. 21 (1892), p. 281.
[2] Ztschr. physiol. Chemie (1887), XII., p. 95.
[3] Landw. Jahrb. (1887), XVI., p. 917.
[4] Ztschr. physiol. Chemie (1887), XII., pp. 145 and 438.
[5] Compt. Rend. (1889), CIX., p. 835.
[6] Journ. f. Landw. 45, p. 173.
[7] Landw. Vers. Stat. 48 (1896), p. 177.
[8] Landw. Vers. Stat. 48 (1896), p. 243.
[9] Die Zersetzung der organischen Stoffe, pp. 12–13.
[10] Landw. Jahrb., vol. II. (1873), p. 107.
[11] Ztschr. des Landw. Vereins in Bayern, March, 1882.
[12] Landw. Vers. Stat., XXX. (1884), pp. 199–216.
[13] Zeitschr., physiol. Chemie, XI. (1887), p. 439.

sults obtained by Tacke,[1] which lead him to believe that "in the oxidation of ammonia, as well as in the reduction of nitric acid to ammonia, conditions may arise where two nascent N atoms can combine into molecular N and escape from the decaying mass." Immendorff[2] sums up the matter as follows: "Aus meinen Versuchen geht, also in erster Linie hervor das durch den Verwesungs-Process, bei reichlichen Gegenwart von Sauerstoff, Stickstoffverluste durch Freiwerden dieses Elementes eintreten können." Schneidewind[3] admits that losses of free nitrogen may at times occur, and further evidence on the subject is furnished by Pfeiffer,[4] Godlewski,[5] Stutzer and Hartleb,[6] and others. After comparing the evidence, Wollny[7] says: "Wird man die, Frage, ob bie der Verwesung Stickstoffhaltiger organischer Stoffe direct oder nach vorgängiger Salpeterbildung freier Stickstoff entbunden wird, also eine offene bezeichnen müssen." He ascribes the differences to the *conditions* of the experiment and believes that because of incomplete aeration there was partial putrefactive decomposition alongside of the decay proper. "And, for the rest," he says, "the number of experiments thus far carried ont are *quite insufficient to offer a final answer to the question. That will* be possible only when the life conditions of the organisms concerned with these processes will be studied more thoroughly, and the chemical composition of the various products of decay will be determined." The author does not emphasize, however, the influence of the organisms themselves and the peculiarities of the different species. The fact that different results were obtained by investigators who worked under similar, but not identical, conditions is in itself sufficient to indicate the status of the subject. An experiment of Gibson's seems to prove the point in question.[8] Gibson inoculated lean beef and blood serum with an infusion from putrefying meat, on the one hand, and with soil solution on the other, no more than a few drops of inoculation being used in each case. He reaches the following conclusions: (1) Liberation of nitrogen may take place during the

[1] Landw. Jahrb. 16 (1887), p. 917.
[2] Landw. Jahrb. 21 (1892), p. 281.
[3] Jour. f. Landw. 45 (1897), p. 176.
[4] Landw. Vers. Stat. 48 (1896), p. 202.
[5] Abstr. in Centr. f. Bact., part II., vol. II. (1896), p. 462.
[6] Centr. f. Bact., part II., vol. 44 (1898), p. 31.
[7] L. c., p. 6.
[8] Amer. Chem. Jour. 15 (1893), pp. 12–18.

process of putrefaction; (2) In the experiments reported, the liberation of nitrogen has been dependent on the inoculation, and certain organisms (found in the putrid flesh) seem incapable of carrying on this process to any marked degree, while others (found in the soil infusion) have produced the liberation of nitrogen independent of the process of nitrification. There is no doubt that the meat infusion and the soil solution contained different organisms, with different physiological activities, and it is but natural that the expression of these activities in the results obtained should be different. And the contradictory results obtained by several careful investigators make it appear that not enough attention had been paid to the agents of decay. That these are a very important factor, at all times to be reckoned with, will appear from the following experiments, carried on in this laboratory:

Losses of Nitrogen in Solutions Free from Nitrates.

These experiments were carried out with pure cultures of the several organisms, and, in one case, with a mixture of soil bacteria. In each case 25 cc. of nutrient bouillon were pipetted off into 200 cc. Erlenmeyer flasks, plugged, sterilized in the autoclave, and, on cooling, inoculated as follows:

1. Sterile.	9. B. pyocyaneus.
2. "	10. "
3. B. coli commune.	11. B. megatherium.
4. " "	12. "
5. B. subtilis.	13. B. New Jersey.
6. "	14. "
7. B. fluorescens liquefaciens.	15. Mixture of soil bacteria.
8. " "	16. " " "

All of the inoculations, with the exception of B. coli commune, made rapid growth. In the latter there was very little preceptible growth, owing, undoubtedly, to the old material used for inoculation. At the endof fifteen days 1 and 2 were clear, 3 and 4 slightly cloudy, 11 and 12 clear, with some white deposit, and the others all turbid, with a greater or less quantity of white, or dirty white deposit. The cultures were then sterilized, and basic lead acetate added to precipitate the bodies of the bacteria. This precipitated, also, the peptone contained in the bouillon. The solutions were filtered, washed and the nitrogen determined according to the Kjeldahl method, in the soluble and the insoluble portion separately, with the following results:

No. of Sample.	Insoluble Nit.	Soluble Nit.	Total Nit.	Average.
1. Sterile	9.00 mg.	50.76 mg.	59.76 mg.	59.53 mg.
2. "	8.70 "	50.61 "	59.31 "	
3. B. coli	11.31 "	48.06 "	59.37 "	59.62 "
4. "	11.46 "	48.41 "	59.87 "	
5. B. subtilis	4.71 "	38.66 "	43.37 "	44.32 "
6. "	6.51 "	38.76 "	45.27 "	
7. B. fluorescens liqu	15 36 "	34.41 "	49.77 "	50.64 %.
8. " "	15.45 "	36.06 "	51.51 "	
9. B. pyocyaneus	14.61 "	39.72 "	54.33 "	52.57 "
10. "	15.96 "	34 86 "	50 82 "	
11. B. megatherium	9.06 "	47.90 "	56 96 "	57.23 "
12. "	9.45 "	48.06 "	57.51 "	
13. B. New Jersey	14.85 "	43.71 "	58.56 "	58.77 "
14. "	14.91 "	44.07 "	58.98 "	
15. Mixture	13.26 "	26.46 "	39.72 "	38.59 "
16. "	13.56 "	23.91 "	37.47 "	

With the exception of B. coli, which made practically no growth at all, the several organisms caused varying and yet considerable losses of nitrogen in the fifteen days of the experiment. The proportionate losses were as follows:

B. subtilis	25.6 %.	B. megatherium	3.9 %.
B fluor. liqu	14.5 "	B. New Jersey	1.3 "
B. pyocyaneus	11.7 "	Mixture	35.2 "

These figures show that, even under the same conditions, the different organisms have produced varying results. No attempt was made to determine whether the losses occurred from the volatilization of ammonia, or of volatile organic nitrogen compounds, from the evolution of oxides of nitrogen, or of free nitrogen. Nevertheless, it can be seen from the amounts of insoluble organic nitrogen produced that the losses were not necessarily greatest where the development was greatest. Thus we find that B. fluorescens liquefaciens has assimilated a greater amount of the soluble nitrogen, originally present in the solution, than any of the other organisms, and yet the losses of nitrogen were not as great here as they were in samples 15 and 16, inoculated with a mixture of soil bacteria. Strangely enough, less insoluble organic nitrogen was found in 5 and 6, inoculated with B. subtilis, than was found in the blanks. It is possible that the peptone was attacked by these bacteria in preference to the other constituents of the bouillon, and destroyed, while comparatively little of it was used to build up their body substance. Comparing B.

megatherium and B. New Jersey, we find that, although there was little growth and but a slight deposit in the flasks inoculated with the former, and abundant growth and a copious deposit in the flasks inoculated with the latter, none the less the loss of nitrogen caused by B. New Jersey was just one-third of that produced by B. Megatherium (1.3 per cent., as against 3.9 per cent.), and in neither case were the losses as considerable as in the other samples. The greatest losses occurred in the inoculation with B. subtilis and with the mixture of soil bacteria, amounting to 25.6 per cent. and 35.2 per cent., respectively. These are enormous losses for so short a period. It will be noticed that in 15 and 16, inoculated in the soil bacteria, the amounts of soluble nitrogen found at the end of the experiment were about half of that originally present in the sample. On the whole, the experiment shows that single species differ as to the effect they produce on the medium in which they grow; that the loss of nitrogen is not proportionate to the amounts rendered insoluble; that the value of the nitrogen solution is decreased, not only by the direct loss, but also by the change of the soluble forms into insoluble and but gradually available forms. Moreover, it appears that when mixtures of bacteria grow in nitrogen solutions they are apt to cause greater losses of nitrogen than are caused by single species. Of course, the work is but preliminary, and further studies will be necessary to allow a better understanding of the subject.

Losses of Nitrogen from Solutions Containing Nitrates.

Denitrification is essentially a reducing process. In its narrower sense, the term is used to designate the complete deoxidation of nitrates with the evolution of free nitrogen; in a broader way, the term is at times employed to designate the partial reduction of nitrates to nitrites. The power of partial reduction is common to many bacteria, and even molds and yeasts. Maasen[1] found that out of the 109 species of bacteria which he examined, 85 had the power of reducing nitrates to nitrites. Wolf[2] attributes this power, also, to molds and yeasts. Sewerin,[3] in his study of the bacteria occurring in horse manure, found that out of 29 species examined, 2 could destroy

[1] Centr. f. Bact., part II., vol. VIII. (1902), p. 152.
[2] Hygienische Rundschon, Jahrg. IX., No. 11, abstr. in Centr. f. Bact., V. (1899), p. 682.
[3] Centr. f. Bact. part II., vol. III. (1897), p. 504.

nitrates completely and 9 could reduce nitrates to nitrites. There have been described, in a manner sufficiently accurate, 17 or 18 organisms capable of destroying nitrates completely. These were found in different places, viz., in manure (horse and cow manure), in the soil, air, flowing water, and even the sea.[1] Denitrifying bacteria are always present in horse manure and seldom absent from cow manure; on the other hand, they are not prominent in the excreta of carnivorous animals, probably because their activities are obscured by the bacteria in the digestive tract of the latter.[2] The denitrifying bacteria found in the soil are also frequently obscured by the others, so that often no fermentation takes place in nitrate bouillon inoculated with soil.

As Lemmermann justly observes,[3] the mere inoculation of nitrate bouillon with soil is not sufficient to show whether denitrifying organisms are present there or not. On the one hand, the nitrate reaction may disappear, even though no denitrifying bacteria be present, and, on the other hand, the nitrate may remain intact notwithstanding the presence of denitrifying bacteria. In the first instance, the nitrates may be converted into organic combinations; in the second instance, the denitrifying bacteria may be suppressed by the others present in the solution. Künnemann[4] was able to observe denitrification in inoculations from five soils out of seven, and in this laboratory denitrification was observed in inoculations from two soils out of three. While there is no doubt, therefore, that denitrifying bacteria are present in moist soils, yet it should be noted that the addition of soil to a water solution of nitrates does not cause denitrification; for a considerable quantity of suitable organic matter must also be present, in order to furnish the denitrifying bacteria the energy required. Hofflich has attempted to determine whether the denitrifying organisms occurring in the soil are derived from the manures applied, or whether there are distinct species of denitrifying bacteria in the soil. He found[5] one or more species of denitrifying bacteria in each of the thirteen soils which he examined, and comes to the following conclusions:

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[1] See Höfflich, Centr. f. Bact., part II., vol. VIII., p. 245; Lemmermann, Kritische Studien über Denitrificationsvorgänge, Jena (1900), pp. 21–22; Baur, Abstr. in Centr. f. Bact., part II., vol. VIII. (1902), p. 587.

[2] Jensen, Centr. f. Bact., part II., vol. IV., p. 448.

[3] L. c., p. 25.

[4] Landw. Vers. Stat. 50, p. 97.

[5] Centr. f. Bact., part II., vol. VIII., p. 404.

1. Denitrifying bacteria are always present in the soil.

2. There is no decided difference between manured and unmanured soils as regards their content of denitrifying bacteria.

3. The denitrifying bacteria present in the soil may survive there even when manure is not applied every year.

4. Soils have no denitrifying bacteria peculiar to themselves; they have the same species that are found in manure.

5. The denitrifying bacteria of the manure, the straw and the soil of any region bear an intimate relation to one another.

Of the bacteria studied in this laboratory, several were isolated from cow and horse manures; others were secured from the bacteriological laboratories of the University of Pennsylvania and of Cornell University, through the kindness of Dr. Abbot and of Dr. V. A. Moore.

The first attempts at the isolation of denitrifying bacteria were made with .32 per cent. solution of sodium nitrate in water, to which varying quantities of horse manure were added. One hundred cubic centimeters of the nitrate solution were placed in small Erlenmeyer flasks, and to the different flasks, 5, 3, 2 and 1 gr., respectively, of horse manure were added. Within twenty-four hours fine bubbles began to rise to the surface in the flasks to which 5 gr. of horse manure had been added; there was scarcely any fermentation where 3 gr. had been added, and none at all in the flasks where 1 gr. had been added. When tested, after seven days, with diphenylamine and sulphanilic acid and naphthylamine for nitrates and nitrites, respectively, it was found that both had disappeared in the flasks to which 5 gr. of manure had been added. On the other hand, there was a strong reaction for nitrites in the flasks to which only 1 or 2 gr. of horse manure had been added. This shows that with the same organisms at the start, the reduction was not the same, and that the greater quantity of organic matter allowed a more complete reduction. Furthermore, in all flasks where the reduction was greatest, the reaction of the liquid was alkaline to litmus paper, while in the flask where the reaction for nitrites was most intense the liquid was found to be neutral to litmus paper. Inoculation was made from these flasks into sterile bouillon containing .3 per cent. of KNO_3. Fermentation with the accompanying fine bubbles became apparent within twenty-four hours. From the fermenting bouillon, reinoculation was made into fresh tubes of nitrate bouillon, and that repeated until five or six reinoculations had been made. In this way most

of the undesirable non-denitrifying bacteria were eliminated and the isolation on agar or gelatine plates made easier. From the last tube agar plates were prepared, and the different colonies, as they appeared, were inoculated into nitrate bouillon. By proceeding in this way it was found that at least two organisms were present in the horse manure, which were capable of destroying nitrates with the evolution of free nitrogen. These were repeated a number of times, until the cultural characteristics became constant. It was found, then, that neither of them had been hitherto described among denitrifying organisms, nor elsewhere, as far as could be ascertained. The two resemble one another very closely in their cultural characteristics, yet show some marked differences. For this reason one was classed as a variety of the other. It was decided to name them after the State where they were found, and one was called Bacillus New Jersey, the other Bacillus New Jersey variety. Before their description is attempted it should be added here that the isolation of these denitrifying organisms was more readily accomplished on agar plates, for many of the accompanying organisms liquefy gelatin, and, growing more rapidly than the denitrifying bacteria, they obscured the latter. It was also found that both B. New Jersey and B. New Jersey var. grow almost as well at room temperature as they do at 28° C. In artificial bouillon made up of nitrate, the required mineral salts and sodium citrate and glucose as the source of energy, the fermentation, while it took place with the ultimate reduction of the nitrate, was nevertheless considerably delayed, and did not appear to be as favorable a medium for the development of the denitrifying bacteria as was the .3 per cent. nitrate bouillon.

Cultural Characteristics of B. New Jersey.

GELATIN COLONIES.

The colonies grew very slowly on gelatin at room temperatures, and but few superficial colonies appear. In four days they appear round, raised, whitish (on blue background), translucent, glistening and very small. On white background the colonies appear yellowish, translucent, with denser centre, and indications of concentric structure. Under low power the superficial colonies appear round, yellowish, entire, granular in structure and denser towards the centre. In eight days the superficial colonies appear lobed and wrinkled,

raised, with smooth centre, dirty-white, with the edges of the lobes somewhat denser. When examined with low magnification the lobes appear to be connected by branchings from the denser round centre, the lobes themselves showing layers of cells parallel to the edge and giving it the appearance of concentric structure. The darker centre seems as if surrounded by a transparent sheath; some of the superficial colonies are 3 mm. in diameter and at times even more. The deep colonies are yellowish, spherical and look like chestnut burrs.

AGAR COLONIES.

In five days the superficial colonies are flat, thin, skin-like, wrinkled like the skin of a pea, irregular, streaming, sometimes growing out in long, narrow strips. Ultimately the colonies spread out considerably, attaining a size (when there are few on the plate) of 6 to 7 cm. With low magnification there appear the yellow centres, somewhat sunken at times, radiating in all directions the streaming bands, which are intersected by lines so as to appear like the structure of some vegetable cell wall. At times the colonies remain round, but show the characteristic wrinkled appearance. In some cases the external zone radiates from the yellowish centre in the form of streamers, resembling turkey feathers. The markings are often parallel to the circumference and more prominent than the longitudinal markings. Below the surface the colonies are spherical, yellowish, often radiating ribs, such as serve as a network for the streaming superficial colonies.

POTATO.

No visible growth, even after two weeks or more.

BOUILLON.

In twenty-four hours, cloudiness. In three days, a slight deposit, moderately turbid, with a thread-like filament adhering to the walls of the tube at the surface.

NITRATE BOUILLON.

In twenty-four hours, moderately turbid. In two days, turbid, with layer of bubbles at the surface, showing that fermentation is far advanced or complete. The deposit rising, in one piece, from bottom on twirling the tube. It is yellowish-white and resembles a piece of precipitated peptone. There is a tendency for the white, suspended particles to settle gradually, with the upper portion of the liquid thus becoming clear.

MILK.

No apparent change for some days. In seven days, a slight layer on surface, with some yellowish deposit. In two weeks, coagulation to a semi-solid, pale, translucent mass. In time the entire mass becomes coagulated.

NITRATE MILK.

In two days, fine bubbles rising to the surface, otherwise no apparent change. In seven days it is somewhat thicker than the milk to which no nitrate had been added. In two weeks, solidification more pronounced, with a clear, yellowish serum on surface, in narrow layer, above semi-solid mass.

GELATIN STAB.

In three days the growth is narrow, filliform along the entire canal, but weakening as it proceeds downward, made up of bright, glistening granules. Crater-like formation around puncture at surface, border raised, glistening, flesh-colored, uneven. In eight days' growth on surface, more extensive than above, lobed, thicker, wrinkled, glistening and translucent at the borders. In depth, essentially as above.

Plate I

Gelatin colonies of B. New Jersey.

1-4. Superficial colonies, natural size. 5. Superficial colony magnified five times. 6 and 7. Internal colonies, slightly enlarged.

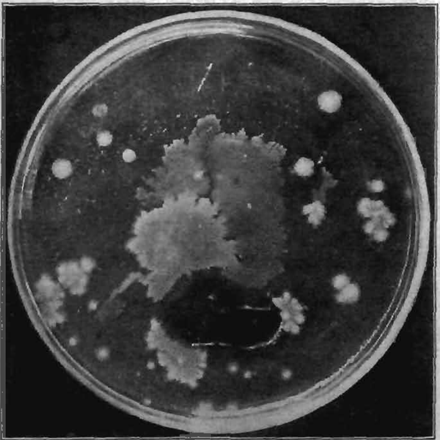

Plate II.

Agar colonies of B. New Jersey.

Photograph of agar plate, showing superficial colonies.

GELATIN SLANT.

In two days' growth, skin-like, glistening; under slight magnification it has the appearance of frosted glass, with an irregular, raised border. In eight days' growth, glistening, borders raised, lobed and fringed, rugose, translucent and pitted (due to many round, whitish particles). It is whitish in transmitted light. At the extreme lower end the border is followed by a narrower, glistening zone, which is smooth and raised.

AGAR STAB.

In twenty-fours' growth, cone-shaped, reaching within a few millimeters of the bottom of the test-tube. At surface, flat, limited, cloudy deposit around punctures. In seven days, the surface growth spreading to the walls of the tube, then dry, pitted, whitish, with raised border. In depth, narrow, cone-shaped, and not reaching the bottom of the tube.

AGAR SLANT.

In twenty-four hours, a wide, bluish-white band of growth, entire surface clouded, condensation water turbid, with more abundant growth near surface. In two days' growth, extensive and flat in the upper portion of the slant, where it can be seen, with a low magnification, to consist of circular units. These are composed of a denser, white, central mass, a narrow, thinner zone, a denser band again, and of wings more irregular in outline, thin and cloudy. In the lower portion of the slant the growth is folded and ridged, as already observed in the colonies on the agar plates: it covers the entire lower portion of the slant, is thin, flat, dry, glistening, with irregular borders. Copious flaky particles in the condensation water.

FERMENTATION TUBES.

Copious growth in lactose, saccharose and glucose bouillon, with heavy turbidity, but in no case was gas production observed.

MORPHOLOGY.

From three-days'-old agar culture the organisms appear as short rods, with rounded ends, occurring singly or in pairs. They stain readily with carbol fuchsin, showing the polar stain, but with greater difficulty with the watery stains. They are decolorized by Gram's method.

MOTILITY.

Both *progressive* and *rotary motility were observed.*

SPORE.

No spore formation was observed.

SIZE.

Repeated measurements show them to be, in young agar cultures, 1.8–2.2–2.4 microns long and .7–.8 microns wide.

BEHAVIOR IN ARTIFICIAL SOLUTIONS.

An artificial solution was prepared similar to that used by Giltay and Aberson,[1] except that different sources of nitrogent were used. The solution contained, in one liter, 2 gr. magnesium sulphate, 2 gr. potassium phosphate, 2 gr. calcium chloride, 5 gr. citric acid, 2 gr. glucose and 2 drops of ferric chloride. Besides these, there was also added in the different samples some nitrogen salt, or peptone, at the rate of 2 gr. per liter. The nitrogenous substances used were potassium nitrate, ammonium chloride, potassium nitrite and peptone.

[1] Archiv. Neerland, vol. XXX., pp. 341–361, quoted by Burri and Stutzer, Centr. f. Bact., part II., vol. I., p. 393.

B NEW JERSEY IN

Artificial solution	without	nitrogen	(in three days)—	Slight turbidity.	
"	"	and	KNO_3	"	Moderate "
"	"	"	KNO_2	"	Slight "
"	"	"	NH_4Cl	"	Moderate "
"	"	"	Peptone	"	Moderate "

IN NINE DAYS.

With no nitrogen—Faint turbidity.
" KNO_3—Strongly turbid, large bubbles, deposit.
" KNO_2—Turbid, slight deposit.
" NH_4Cl—Turbid, brownish deposit, layer on surface.
" Peptone—Moderate turbidity, slight deposit, slight pellicle.

It appears from the above that the growth with potassium nitrite as the only source of nitrogen was by no means as extensive as it was where potassium nitrate was used. The growth where ammonium chloride was used was rather peculiar. Crystals were deposited on the walls of the tube and the deposit was more considerable than it was in the other cases, and brownish in color. There was a slight development where no nitrogen at all was added, and it is possible that it was due to the slight amount of nitrogen probably present in the water (tap water was used here). The peptone did not, apparently, offer as good a source of nitrogen as did the potassium nitrate or the ammonium chloride, and in no case was there as much development as in ordinary bouillon. Tubes of bouillon containing 2 gr. of potassium nitrite per liter showed fermentation, with the accompanying fine bubbles, in two days.

B. NEW JERSEY VAR.

This organism differs from B. New Jersey, particularly in the form of its colonies on agar. The deep colonies are yellowish and of mulberry form, and considerably smaller than those of B. New Jersey. The superficial colonies are round or roundish, somewhat loosely woven, yellowish, tend to be punctiform at centre, soft, raised, tend to be wrinkled, but not as B. New Jersey, and do not send out streamers. Older colonies are lobed, lobes not deeply incised, with short lines radiating towards the circumference. There are also

some longer, wavy lines nearer the circumference, and at right angles to it. The incisions of the lobes, while not deep, are yet continued as linear depressions almost to the centre, thus producing the appearance of folds.

The appearance in artificial solutions is, also, somewhat different, as is shown below:

With KNO_3—B. New Jersey—Moderately turbid, slight deposit.
" " " " " var.—Strongly turbid deposit, bubbles.
" KNO_2—B. New Jersey—Turbid, slight deposit.
" " " " " var.—Turbid deposit, layer on surface, bubbles.
" NH_4Cl—B. New Jersey—Turbid, brownish deposit.
" " " " " var.—Turbid, brownish deposit, layer on surface.
" Peptone—B New Jersey—Moderate turbidity, slight deposit.
" " " " " var —Moderate turbidity, slight deposit.
" no nitrogen—B. New Jersey—Slight turbidity.
" " " ' " " var.—Slight turbidity.

When tested a few days later with diphenylamine there was no reaction in either the nitrate or nitrite tubes. Further differences were observed in ordinary bouillon, where B. New Jersey var. shows very often a tendency to form a pellicle on the surface of the medium, while B. New Jersey shows no such tendency.

The Isolation and the Cultural Characteristics of Symbiotic Denitrifying Bacilli 20 and 21.

These two organisms were isolated from cow manure, and, until further study of them is made, will be called by their laboratory numbers, B. 20 and B. 21. B. 21 resembles greatly B. denitrificans, described by Burri and Stutzer,[1] which, in symbiosis with B. coli commune, is capable of destroying nitrates with the evolution of free nitrogen. B. 21 is entirely distinct from B. coli or B. typhosus, which can take its place in symbiotic denitrification, as will be seen by the cultural characteristics presented here. A discussion of the physiology of symbiotic denitrification and its distinction from other denitrification processes will be given below. In this place it need only be said that the two organisms are not capable of destroying nitrates when growing alone.

[1] Centr. f. Bact, part II., vol. I. (1895), p. 257.

For the purpose of isolation of denitrifying bacteria, .3 per cent. nitrate bouillon was inoculated with a bit of cow manure obtainued on the College Farm. In eighteen hours there was a copious evolution of nitrogen, as evidenced by the numerous minute bubbles rising to the surface and forming there a layer of foam. After one or two reinoculations, agar plates were prepared, and in three days, at the room temperature, there were at least three distinct organisms apparent, according to the appearance of the colonies:

1. Smooth, spreading, flat, skin-like, entire, with edges sharply cut.

2. Yellowish-white, thick, raised, irregular, glistening colonies.

3. Spreading, flat, glistening, irregular, warty colonies.

The last appeared in greater numbers than the others. On inoculating them into nitrate bouillon, none proved capable of denitrification. On making new plates from fermenting nitrate bouillon tubes, there were observed among the others flat, thin, fibrous colonies, which, on being inoculated into nitrate bouillon, showed, in some cases, at least, active denitrification. Plates prepared from the latter showed at least two kinds of colonies; one, the branched, thin, fibrous colonies, the other, thin, irregular, spreading colonies, with edges sharply cut and growing very rapidly. Because of the absence of the characteristic B. coli colonies, it was not thought at the time that there was a case of symbiotic denitrification at hand. It was soon noticed, however, that not all inoculations from the fibrous colonies, which were at first believed to be the denitrifying organisms, produced denitrification, and that the plates from the tubes which did ferment invariably contained two organisms. The second organism, producing the flat, spreading colonies, while it made its appearance somewhat later than the other, grew so rapidly as to cover the entire plate in two or three days, and made an uncontaminated inoculation almost impossible. Fresh agar plates were then prepared, and careful inoculations made from the fibrous colonies before the others became visible; and, similarly, nitrate-bouillon tubes were also inoculated from the flat, spreading colonies when they made their appearance. Out of the two tubes inoculated from the former there was no fermentation at all in one after ten days, and in the other, bubbles appeared on the fifth or sixth day instead of the normal twenty-four hours. On plating this second tube the two organisms were found, and it became clear that there was contamination in that tube. In the inoculations from the thin, flat,

spreading colonies no fermentation appeared. When, however, to one of these non-fermenting tubes a trace of bouillon was added from the tubes inoculated with the fibrous colonies, fermentation soon set in. In view of the fact that these organisms grew rapidly when alone, but prodnced no denitrification, and showed the same characteristics when reinoculated for several generations, and that when inoculation was made from one into the other, or when the two were inoculated at the same time into fresh nitrate bouillon, fermentation invariably set in, it was concluded that a case of symbiotic denitrification was here dealt with. Furthermore, plates prepared from each showed but one kind of colonies, which, when inoculated together, produced fermentation and produced none when kept separate.

Cultural Characteristics of B. 20.

AGAR COLONIES.

Deep colonies—white, small (less than 1 mm.), entire, irregularly round to elliptical. Surface colonies—slightly whitish and scarcely raised, very irregular, tufted and feathery, with very small, white centres. In some cases they have the appearance of fibrous, matted roots. Single colonies measure more than 1cm. across. In some smaller colonies the branches are wider at the tip.

NITRATE BOUILLON.

Turbid, almost white, film on surface very fine and slightly shimmering when held at the proper angle. Odor—none, or faint and unpleasant. In three days, a moderate white deposit.

BOUILLON.

In three days, turbidity and a slight white deposit.

NITRATE BOUILLON.

In three days, turbid, with a moderate white deposit.

AGAR STAB.

Very broad, tapering line of growth, reaching, in seven days, to the bottom of the tube; growth on surface, whitish, scarcely raised, glistening, ultimately covering the entire surface.

AGAR STROKE.

Growth whitish, thin, glistening, covering entire surface, tufted at the top, condensation water turbid, with white deposit.

POTATO.

Growth slightly brownish band, somewhat raised and broader at the base.

Cultural Characteristics of B. 21.

AGAR COLONIES.

Deep, small, round or elliptical, white, rather irregular and resembling *those of B. 20. Surface, spreading, thin, flat, skin-like,* irregular, attaining a diameter of several cm. if unimpeded in their growth. The edges are usually toothed or incised. The surfaces show a bluish shimmer when held up to the light.

NITRATE BOUILLON.

Moderately turbid, violet, shimmering film rising some distance up the walls of the tube, and tending to wrinkle when the tube is inclined.

BOUILLON.

In three days, slight deposit, turbidity, slight film.

NITRITE BOUILLON.

Turbid, moderate white, flaky deposit, fine bubbles rising to the surface, showing active fermentation.

AGAR STAB.

Tapering band of growth, narrower than in B. 20, extending not quite to the bottom of the tube; surface growth, white, glistening, irregular.

AGAR STROKE.

Irregular band of growth, wider at the base, outlines rather sharp and toothed, transparent, slightly whitish, condensation water turbid, with white, flaky deposit and film.

POTATO.

Band of growth brown, raised and covering about one-third of the surface.

FERMENTATION IN TUBES.

Abundant growth in lactose, glucose and saccharose bouillon, inoculated with either B. 20 or B. 21. In neither case was fermentation observed.

ODOR.

In the cultures of B. 20 scarcely any odor was noticed, and if any at all, a faint, unpleasant odor. In the cultures of B. 21 a distinct, rather pleasant odor.

BACTERIA IN ARTIFICIAL BOUILLON.

The artificial bouillon was made up, as already described, of the mineral salts and of sodium citrate and glucose; various sources of nitrogen were used, as with B. New Jersey. It was found that B. 20 and B. 21 showed striking differences in this respect, as the following columns will show:

B. 20.

With KNO_2 —Clear, no growth.
" NH_4Cl — " " "
" Peptone—Growth, turbidity, deposit.

B. 21.

With KNO_2 —Heavy deposit, turbidity, shimmering film, nitrite reduced.
" NHCl —*Strong turbidity, waxy layer on surface, dirty white deposit,* crystals on walls of tube.
" Peptone—Heavy deposit, turbidity, shimmering film.

MORPHOLOGY.

B. 20.

Short rods, with rounded ends, occurring singly or in twos; length, .8–1.3 microns, with .5 microns. Stains uniformly with carbol fuchsin, and with greater difficulty with the watery stains. There is no progressive motility in hanging drop, but many individuals showed vibratory motion.

B. 21.

Very short rods, with rounded ends, occurring singly or in twos. They take the polar stain with carbol fuchsin, and are .6–1.2 microns long and .5–.6 microns wide. In hanging drop from either nitrite bouillon or agar, progressive motility is shown. The flagella are polar.

For the sake of comparison, the cultural characteristics of the two symbiotic, denitrifying bacteria, B. coli commune and B. denitrificans, described by Burri and Stutzer,[1] are presented here.

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[1] Centr. f. Bact., part II., vol. I., (1895), pp. 354–360.

B. Coli Commune.

FORM AND DIMENSIONS.

From two-days'-old gelatin plate—plump rods, with rounded ends, 1–1½ microns long and ¾ micron wide. From bouillon the organisms are larger, attaining a length of 2½ microns. The plasma is homogeneous and takes the stain easily and uniformly.

MOTILITY.

From fresh plates, very active, from bouillon, less so.

AGAR STAB.

Narrow growth, a long line of puncture in lower, as well as in upper portion. A round puncture on surface, a thin, skin-like, glistening, smooth growth, soon extending to the walls of the tube.

AGAR STROKE.

Growth soft (slimy), strongly glistening, scarcely raised, with smooth, partly-toothed edges.

POTATO.

In two days, at 37° C., the characteristic moist, glistening growth of dirty-yellow color. The same at room temperature.

BOUILLON.

Evenly turbid, with a dirty-white deposit on the bottom of the tube, which easily breaks into fine particles on shaking. No pellicle on surface even after several weeks.

PIGMENT AND SPORES.

No pigment or spore formation noticed. Cultures several weeks old, easily sterilized by a single boiling.

FERMENTATION TUBES.

According to Pflügge,[1] B. coli produces gas in lactose and glucose bouillon.

Cultural Characteristics B. of Denitrificans.

FORM AND DIMENSIONS.

The organisms are 1½–2½ microns long and ¾ micron wide. In bouillon cultures they may attain a length of 2–3 microns.

MOTILITY.

Usually absent. Where present it is usually very active. In two days old bouillon cultures (at 30° C.) the greatest part are non-motile.

AGAR PLATES.

Surface colonies, very thin, skin-like growth. There is a somewhat denser, but not well-defined, portion in the centre. When only a few colonies are present on the plate they may attain in twenty-four to thirty hours, at 37° C., a diameter of 2 to 3 cm. The colonies are usually roundish, but outgrowths occur, and where the colony presses on another, polygonal forms may arise.

AGAR STAB.

Growth in upper portion of stab more pronounced than in lower portion; at times the growth does not extend along the entire length of the canal. On the surface there is a grayish fat, glistening deposit, which, in one or two days, reaches the walls of the tube.

[1] Micro-organismen.

AGAR STROKE.

Entire agar surface covered rapidly (at 30° C. in twenty-four hours) by a thin, grayish growth.

POTATO.

In two days, at room temperature, there is scarcely any growth. At 30° C., after two days, there is a 2 to 3 mm. wide band, glistening, scarcely raised, dirty brown-red, becoming more intensely colored in the following days. At room temperature the formation of pigment is less pronounced.

BOUILLON.

Becomes turbid, at 30° C., in twenty-four hours, to complete non-transparency, deposit reddish-white, which easily breaks up on shaking. No pellicle is formed, although a tendency in that direction is evidenced.

BEHAVIOR TOWARDS STAINS.

Water methyl violet colors the organisms readily, but not intensely. With carbol fuchsin there is an evident tendency to polar-staining. In single cases this is quite pronounced. Cultures on alkaline potatoes, at 37° C., produce a brown-red, variable pigment. Gelatine and agar show a dirty green fluorescence. No spore formation was observed.

By comparing B. 20 and B. 21 in the B. coli and with B. denitrificans, respectively, it will be observed that B. 20 and B. coli are distinct organisms, and that B. 21 and B. denitrificans show considerable differences, which make it appear that the two are not identical, and further study will be required to determine this point. Some further data as to the identity of B. 20 were obtained by comparing its growth in artificial bouillon with that of B. coli, a culture of which was secured through the kindness of Dr. Moore, of Cornell University.

GROWTH IN ARTIFICAL BOUILLON, WITH SOURCE OF NITROGEN, AS:

KNO_3—B. coli.—Turbid, film on surface.
" B. 20—Clear, no growth.
KNO_2—B. coli.—Turbid, slight deposit.
" B. 20—Clear, no growth.
NH_4Cl.—B. coli.—Turbid, flocculent, heavy deposit, film.
" B. 20—Clear, no growth.
Peptone—B. coli.—Turbid, white deposit, film.
" B 20—Growth, turbidity, deposit.

It will be seen from the above that B. coli can grow very well in solutions containing the mineral salts, citrate and glucose, and either nitrate, nitrite or an ammonium salt as its only source of nitrogen, while B. 20 could not grow at all under these conditions, but developed and grew rapidly in the same solution containing peptone as the only source of nitrogen. Ammonium chloride appeared to be a more favorable source of nitrogen for B. coli than either potassium nitrate or potassium nitrite, and potassium nitrate appeared to be fully as good as peptone. On the other hand, the growth with potassium nitrite as the only source of nitrogen was not as extensive.

The Carbon Compounds Best Suited for Denitrification.

A certain amount of energy is required to tear apart the atoms in the nitrate molecules. Unless such energy is at their disposal, the denitrifying bacteria cannot effect the decomposition of nitrates. Being saprophytic, they depend for their source of energy on organic compounds, elaborated by the plant (or animal) world, yet there are some organic componnds which they prefer to others. The different denitrifying bacteria thus far described show very considerable differences in this respect. Lemmermann[1] has summed up the work of a number of investigators up to 1900 on this particular point, and it is not necessary to go into detail here. The work of Jensen, Stutzer and Hartleb, Spieckermann, Stoklasa, Pfeiffer and Lemmermann is discussed by him, and to these should also be added the work of Stoklasa and Vitek,[2] Massen[3] and Salzmann,[4] which appeared since the publication of Lemmermann's booklet. It seems that certain organic

[1] L. c., p. 27.
[2] Centr. f. Bact., part II., vol. VII. (1901), p. 257.
[3] Centr. f. Bact., part II., vol. VIII. (1902), p. 152.
[4] Centr. f. Bact., part II., vol. VIII. (1902), p. 347.

acids are a very suitable source of energy, carbohydrates, like fructose *and glucose, are readily utilized by a number of denitrifying bacteria,* as are some higher alcohols and amido derivations of the fatty acids. Spieckermann[1] obtained some interesting results with several series of organic compounds. He found that glucose could be utilized very readily by the four denitrifying bacteria with which he worked, and *namely, B. pyocyaneus B., B. fluorescens liquefaciens and two denitrifying* organisms which he islolated from manure, but which he has not described.

In a series of solutions containing, besides the mineral salts, 5 per cent. of—

> Glycerin—CH_2OH, $CHOH$, CH_2OH.
> Glycerose—CH_2OH, $CHOH$, CHO.
> Glyceric acid—CH_2OH, $CHOH$, $COOH$.
> Tartronic acid—$COOH$, $CHOH$, $COOH$.

He found that there was no growth at all in glycerose and tartronic acid, and growth and denitrification in the solution of glyceric acid and glycerin, in the former, however, only by B. pyocyaneus and B. *fluorescens liquefaciens. On examining the clear solution of glycerose,* he found that the bacteria had been destroyed there, while in the tartronic acid the bacteria were still capable of development when placed in a glucose solution. It appears from this that the aldehyde glycerose acted as a poison to all organisms, and that tartronic acid, differing from glyceric acid by the replacement of the carboxyl group by CH_2OH did not offer a suitable source of energy to the denitrifying organisms. Still greater individual peculiarities were observed in the following series:

Mannit........ Sorbit........ Dulcit........	$CH_2OH\ (CHOH)_4\ CH_2OH$
Glucose....... Fructose...... Galactose.....	$CH_2OH\ (CHOH)_4\ CHO$.
Muric acid...	$COOH\ (CHOH)_4\ COOH$.

The results obtained were as follows:

Mannit—Complete denitrification by the four organisms in three days.

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[1] **Lemmermann, l. c., p. 28**

Sorbit—No growth by B. pyocyaneus and B. fluorescens liquefaciens, while the two organisms isolated by him from manure destroyed the nitrate completely in three days.

Dulcit—No growth by B. pyocyaneus and B. fluorescens liquefaciens; complete denitrification by the others in four days.

Glucose—Complete denitrification by all in four days.

Fructose—Complete denitrification by all in three days.

Galactose—Complete denitrification by all except B. fluorescens liquefaciens in three days; the latter failed to grow.

Mucic acid—No growth hy any of the four.

In this case the aldoses glucose and galactose seemed to be favorable sources of carbon, as was the ketose fructose. The higher alcohols also proved suitable, yet two of the organisms failed to grow in sorbit and dulcit. The two carboxyl groups of the mucic acid inhibited growth, also, in this case. It is not likely that the cause of the failure lies in the *number* of carboxyl groups present, for citric acid, which contains three carhoxyl groups, has been found to be, also, in this laboratory, a very suitable source of carbon, and it must be assumed that it is the *position* of the carboxyl group in mucic or tartronic acid which renders these compounds an unfavorable source of energy. Spieckermann found, also, amido-acids, and hydroxy acids to be favorable sources of carbon. Of the acids of the paraffine series, formic and acetic acids proved unsuitable, while propionic, butyric, isobutyric, valerianic and capronic could be utilized by all four organisms. Spieckermann also tried saturated and unsaturated alcohols and a number of pentoses. According to Stoklasa,[1] a considerable number of denitrifying bacteria can make use of butyric, succinic, malic, lactic and citric acids, and also d-glucose, l-xylose, l-arabinose, saccharose, maltose and lactose for their development. Among the organisms which he ennumerates is, also, B. pyocyaneus, but the work in this laboratory indicates that B. pyocyaneus is not capable of utilizing all of the substances mentioned by him, as will be shown below.

Salzmann[2] studied the behavior of B. Hartlebi and B. Stutzeri towards the carbon compounds, and he also found distinct individual peculiarities. Thus, B. Hartlebi could utilize saccharic and formic acid, while B. Stutzeri was unable to do that. Furthermore, it was unable to make use of arabinose, xylan, glucose, inulin, lactose and

[1] Centr. f. Bact., part II., vol. VII. (1901), p. 257.

[2] Dissertation, Königsberg (1901), Abstr. in Centr. f. Bact., part II., vol. VIII., p. 847.

maltose, while B. Hartlebi developed in solutions of these without difficulty. B. Stutzeri was also unable to utilize mannit, isoamyl and isobutyl alcohols, which proved suitable for B. Hartlebi. The latter could also make use of hippuric and uric acid, which was not true of B. Stutzeri.

Behavior of B. New Jersey Towards Organic Acids.

In order to determine the comparative value of several organic acids *as a source of carbon for* B. New Jersey, a solution of mineral salts was prepared, which contained, per liter:

2	grams	$Mg\ So_4$
2	"	$K_2\ H\ Po_4$
0.2	"	$Ca\ Cl_2$
2	"	$K\ No_3$
2	drops of	$Fe_2\ Cl_6$

As the source of carbon there, as added in the different cases, succinic, tartaric, lactic or citric acid, all at the rate of 5 gr. per liter, and in some cases asparagine, at the rate of 2 gr. per liter. The arrangement of the experiment was as follows:

1. Mineral salts + lactic acid.
2. " + " + $Ca\ Co_3$
3. " + " + Asparagine.
4. " + " + " + $Ca\ Co_3$

5. Mineral salts + succinic acid.
6. " + " + $Ca\ Co_3$
7. " + " + Asparagine.
8. " + " + " + $Ca\ Co_3$

9. Mineral salts + tartaric acid.
10. " + " + $Ca\ Co_3$
11. " + " + Asparagine.
12. " + " + " + $Ca\ Co_3$

13. Mineral salts + citric acid.
14. " + " + $Ca\ Co_3$
15. " + " + Asparagine.
16. " + " + " + $Ca\ Co_3$

The calcium carbonate, where used, was added at the rate of .5 gr. to each flask, which contained, in every case, 200 cc. of liquid. The different acids in solution were neutralized with sodium hydroxide until they were faintly alkaline to phenolphtaleine, the degree of

alkalinity being nearly the same in every case. After the 200 cc. portions of the respective solutions were placed in the corresponding flasks, the latter were plugged with cotton stoppers and sterilized in the autoclave. After sterilization it was discovered that the potassium nitrate was omitted in flasks 1, 2, 3 and 4; nevertheless, the inoculation was proceeded with, it being deemed inadvisable, at the time, to make up new solutions. After inoculation with B. New Jersey the several flasks were placed in the incubator and kept at 28° C. In two days the following was observed:

Flask 1. Clear.
" 2. "
" 3. Turbid.
" 4. " flaky deposit.

" 5. Clear.
" 6. "
" 7. Turbid, flaky masses and skin-like membrane.
" 8. " " " more limited

" 9. Clear.
" 10. "
" 11. Turbid, dirty white deposit, bubbles.
" 12. " " " " copious bubbles.

" 13. Turbid, flaky deposit.
" 14. " " "
" 15. " liquid yellowish, bubbles.
" 16. " copious bubbles, deposit.

Leaving the lactic acid out of consideration, it appears that only citric acid proved suitable as a source of energy when used alone, since 5, 6, 9 and 10 remained clear and showed no growth, while, on the other hand, citric acid, in 13 and 14, without the addition of any other organic compound, proved efficient as a source of carbon. In 3, 4, 7, 8, 11, 12, 15 and 16, where asparagine was also added, there was rapid growth, with the ultimate disappearance of the nitrates, and furthermore, where calcium carbonate was added, there was greater development; thus, in 12 and 16 there was a more intense growth than in the corresponding 11 and 15, where no calcium carbonate was used. It was also observed that bubbles first appeared in 15 and 16, then in 7 and 8, and finally in 11 and 12. In fifteen days after inoculation the several flasks appeared as follows:

1. Clear.
2. Cloudy.
3. Turbid, floating pellicles, dirty white deposit.
4. " " " deposit more abundant.

5. Clear.
6. Turbid, some deposit.
7. Moderately turbid, liquid yellowish, flaky deposit.
8. Turbid, bluish-white layer along walls of flask, deposit more abundant.

9. Clear.
10. "
11. Turbid, deposit paraffine like.
12. Clear, deposit more abundant.

13. Turbid, large bubbles, slight deposit.
14. " " " deposit.
15. " liquid pinkish, crystalline deposit, paraffine-like particles on surface.
16. Turbid, liquid pinkish, crystalline deposit, paraffine-like particles on surface.

It will be noticed here that in flask 6, where succinic acid was used as the only source of carbon, there was growth, while there was none in flask 5, showing that the presence of calcium carbonate allowed B. New Jersey to utilize succinic acid. There was a slight cloudiness in 2, indicating a very limited growth, and probably due to the trace of combined nitrogen contained in the reagents. It has been found, in other experiments, that lactic acid is a very suitable source of carbon to many denitrifying bacteria. Tartaric acid alone proved altogether unsuitable for B. New Jersey. After sterilization the several cultures were filtered and the nitrogen in the insoluble residue on the filters determined, according to the Kjeldahl method, with the following results:

Insoluble organic	N in	No.	1—0	mg.	Insoluble organic	N in	No.	9—0	mg.
"	"	"	2—0.3	"	"	"	"	10—lost	"
"	"	"	3—2.38	"	"	"	"	11—4.77	"
"	"	"	4—1.83	"	"	"	"	12—8.30	"
"	"	"	5—0	"	"	"	"	13—2.20	"
"	"	"	6—0 96	"	"	"	"	14—2.00	"
"	"	"	7—1.93	"	"	"	"	15—7.84	"
"	"	"	8—4.22	"	"	"	"	16—9.18	"

The quantities of nitrogen recovered as insoluble organic were, with one exception, greater in the samples where calcium carbonate was used, as against the corresponding samples where none was employed. There were 9.18 mg. of nitrogen found as insoluble organic in

16, as against 7.84 mg. in 15; 8.30 mg. were found in 12, as against 4.77 mg. in 11, and 4.22 mg. were found in 8, as against 1.93 mg. in 7. The favorable influence of calcium carbonate is also observed in 2, as compared with sample 1, and in sample 7, compared with sample 6. The amount of insoluble organic nitrogen found is proportionate to the development of the bacteria, although, as far as denitrification proper is concerned, the losses are not necessarily greatest where the amount of insoluble organic nitrogen formed is the greatest. On the contrary, where the decomposition of the nitrates takes place more slowly, more ammonia is formed and more of the nitrate nitrogen is utilized to build up the bodies of the bacteria. In 1, 5 and 9, where no growth took place, no insolubie organic nitrogen was found, and, strangely enough, .3 mg. were found in 2, where no nitrogen was added to the solution. It may be that traces of nitrogen were present in the reagent (they conld not have been more than traces), yet, admitting that, it is scarcely possible that the 3 mg. were all derived from the reagents, for the blank determinations would have showed the presence of 3 mg. of nitrogen. It is more likely that the organisms obtained part of this nitrogen from the air, as will be shown to have occurred in other experiments reported here. It is significant *that in 1, without the addition of* $CaCo_3$, *such limited fixation of* atmospheric nitrogen did not take place. Comparing the structural formulas of lactic, succinic, tartaric and citric acids, we find the following relations:

Lactic......C_2H_4 (OH) COOH	Tartaric....C_2H_2 $(OH)_2$ $(COOH)_2$
Succinic....C_2H_4 $(COOH)_2$	Citric.......C_3H_4 (OH) $(COOH)_3$

Succinic acid was evidently a better source of carbon than tartaric acid, but the two are closely related, the latter being derived from the former by the replacement of two hydrogen atoms by hydroxyl groups. The tribasic citric acid and the monobasic lactic acid are also hydroxy acids, yet they are better sources of carbon than either succinic or tartaric acid.

Further studies in this direction were carried out in another experiment, where, besides B. New Jersey, also B. pyocyaneus was used. A mutrient solution was prepared, containing, per liter, .2 gr. $MgSo_4$, .2 gr. K_2 HPO_4, .02 gr. $CaCl_2$, and 2 gr.KNO_3. Besides these, there was added in each case some organic compound at the rate of 5 gr. per liter to serve as the source of energy. Where organic acids were used, sodium hydroxide was added to a faintly alkaline reaction to phenolphtaleine, so that the sodium salt of the respective acid was

really used. In the case of citric acid, however, calcium citrate was used instead of sodium citrate, and calculated to correspond to 5 gr. of citric acid per liter. Two hundred cc. were taken in each case, placed in 500 cc. Erlenmeyer flasks, 5 gr. of $CaCO_3$ added, plugged and sterilized in the autoclave. After sterilization, asparagine was added to certain flasks at the rate of 2 gr. per liter, and again sterilized in the Arnold sterilizer. Pure filter paper, cut in thin strips, was used as the source of cellulose. The arrangement of the experiment was as follows:

1.	Inorganic	solution,	+ sterile.				
2.	"	"	+ B. New Jersey.				
3.	"	"	+ citrate,		B.	New	Jersey.
4.	"	"	+ cellulose,		"	"	"
5.	"	"	+ dextrin,		"	"	"
6.	"	"	+ starch,		"	"	"
7.	"	"	+ glucose,		"	"	"
8.	"	"	+ lactose,		"	"	"
9.	"	"	+ saccharose,		"	"	"
10.	"	"	+ maltose,		"	"	"
11.	"	"	+ asparagine,		"	"	"
12.	"	"	+ citrate +	asparagine,	B.	New	Jersey.
13.	"	"	+ cellulose +	"	"	"	"
14.	"	"	+ dextrin +	"	"	"	"
15.	"	"	+ starch +	"	"	"	"
16.	"	"	+ glucose +	"	"	"	"
17.	"	"	+ lactose +	"	"	"	"
18.	"	"	+ saccharose +	"	"	"	"
19.	"	"	+ maltose +	"	"	"	"
20.	"	"	+ asparagine sterile.				
21.	"	"	+ citrate,	B. pyocyaneus.			
22.	"	"	+ cellulose,	"			
23.	"	"	+ dextrin, B.	"			
24.	"	"	+ starch,	"			
25.	"	"	+ glucose,	"			
26.	"	"	+ lactose,	"			
27.	"	"	+ saccharose,	"			
28.	"	"	+ maltose,	"			
29.	"	"	+ asparagine,	"			
30.	"	"	+ citrate +	asparagine,	B. pyocyaneus.		
31.	"	"	+ cellulose +	"	"		
32.	"	"	+ dextrin,	"	"		
33.	"	"	+ starch +	"	"		
34.	"	"	+ glucose +	"	"		
35.	"	"	+ lactose +	"	"		
36.	"	"	+ saccharose +	"	"		
37.	"	"	+ maltose +	"	"		
38.	"	"	+ citrate, B. New Jersey.				

In four days after inoculation the following observations were made:

1 to 5 inclusive, clear.
6 to 9 inclusive, cloudy.
10. Signs of growth.
11. Turbid, bubbles appearing.
12. " " large.
13. " "
14. " "
15. " "
16. Clear.
17. " signs of growth.
18. Turbid, bubbles.
19. Clear.
20. "
21. Cloudy.
22. Clear.
23. Cloudy.
24. Cloudy.
25. "
26. Clear.
27. "
28. Cloudy.
29. " a few bubbles.
30. Turbid, bubbles.
31. " "
32. " "
33. " "
34. " "
35. Faintly cloudy.
36. Turbid, bubbles.
37. " "
38. Faintly cloudy.

A comparison of the solutions inoculated with B. New Jersey with those inoculated with B. pyocyaneus reveals the fact that the latter organism can make use of a greater variety of organic substances for its development. In four days B. New Jersey produced scarcely any growth in the flasks where asparagine had not been added, and even in the latter the growth was not constant. With B. pyocyaneus there was growth in every flask where asparagine had been added, and signs of growth in some of the others. In eight days the appearance of the several flasks was as follows:

One to 5, inclusive, clear; 6, cloudy; 7 to 10, inclusive, clear; 11 to 16, inclusive, turbid and bubbles; 17, clear; 18, turbid; 19, 20, 22, 24, 26 and 27, clear; 21, 23 and 25, cloudy; 28 to 37, inclusive, bubbles, fermentation, probably complete; 38, slightly cloudy. Three days later 6 was found to be turbid, and 21, 23 and 25 showed farther growth. In two weeks, also, 3 showed vigorous growth, and fermentation was observed in 21, 23 and 25. From this time no essential changes were observed through the summer. At the end of four months the cultures were tested for nitrates and nitrites, with the following results:

Nitrates and nitrites absent in 3, 12, 14, 15, 16, 17, 18, 21, 25, 30, 34 and 37. In the other cases diphenylamine gave a more or less pronounced reaction. B. New Jersey destroyed the nitrate completely in the presence of citrate alone, but did not do so with asparagine alone, nor with asparagine and cellulose together, and not even with asparagine and maltose together. B. pyocyaneus, on the other hand, could make use of glucose alone for the destruction of the nitrate, but did not cause complete denitrification, as did B. New Jersey in

the presence of dextrin and asparagine, starch and asparagine, lactose and asparagine, saccharose and aspargine. Like B. New Jersey, it caused complete denitrification with glucose and asparagine; and unlike B. New Jersey, it caused complete denitrification with maltose and asparagine.

The cultures were sterilized and filtered, and the insoluble organic nitrogen left on the filter determined. After subtracting from the several determinations the amount of nitrogen found in the blanks, the following quantities were obtained:

Insoluble Organic Nitrogen.

1......	..... mg.	11......	2.0 mg.	21	1.5 mg.	31......	6.7 mg.
2......	..... "	12	1.3 "	22	..... "	32......	4.5 "
3	.4 "	13......	1.6 "	23......	..... "	33	9.1 "
4......	..... "	14......	1.3 "	24	.9 "	34	1.7 "
5......	..... "	15......	6.4 "	25......	.5 "	35......	8.2 "
6......	4.0 "	16......	1.7 "	26......	..... "	36	9.0 "
7......	..... "	17......	..... "	27......	..... "	37......	8.0 "
8......	..... "	18......	1.9 "	28	1.9 "	38......	... "
9......	..... "	19......	..... "	29	6.8 "		
10......	.6 "	20......	..... "	30......	9.9 "		

The two organisms again display here an individuality of their own; notwithstanding this, they show common characteristics. B. New Jersey has not, on the average, shown as much development as B. pyocyaneus, as is indicated by the subjoined figures:

B. NEW JERSEY.		B. PYOCYANEUS.	
Citrate........................	.4 mg.	Citrate	1.5 mg.
Starch........................	4.0 "	Starch........................	.9 "
Maltose........................	.6 "	Glucose........................	.5 "
Asparagine........................	2.0 "	Maltose........................	1.9 "
Citrate + asparagine......	1.3 "	Asparagine........................	6.8 "
Cellulose + "	1.6 "	Citrate + asparagine.......	9.9 "
Dextrin + "	1.3 "	Cellulose + "	6.7 "
Starch + "	6.4 "	Dextrin + "	4.5 "
Glucose + "	1.7 "	Starch + "	9.1 "
Saccharose + "	1.9 "	Glucose + "	1.7 "
		Lactose + "	8.2 "
		Saccharose + "	9.0 "
		Maltose + "	8.0 "

B. New Jersey has developed with an appreciable production of insoluble organic nitrogen in ten cases, and B. pyocyaneus in thirteen cases. The average amount in the former case was 2.12 mg., and in

the latter 5.28 mg. With citrate B. New Jersey effected a complete destruction of the nitrate with the formation of only .4 mg. of insoluble organic nitrogen, while B. pyocyaneus produced, under the same circumstances, 1.5 mg. of insoluble organic nitrogen, and since that nitrogen is contained in the bodies of the bacteria, it must be concluded that either the body substance of B. New Jersey is poorer in nitrogen, or that B. pyocyaneus must be present in greater numbers in order to destroy the same amount of nitrate. With starch alone there was considerable growth, both with B. New Jersey and B. pyocyaneus, but in the former case more insoluble organic nitrogen was formed, and in neither case was there a complete destruction of the nitrate. B. New Jersey showed scarcely any growth with maltose, although some insoluble organic nitrogen was formed, and a larger amount was formed by B. pyocyaneus. A complete reduction of the nitrate was not effected in either case. With asapargine alone B. New Jersey produced 2 mg. of insoluble organic nitrogen, and B. pyocyaneus 6.8 mg. With citrate and asparagine B. New Jersey produced 1.3 mg. of insolnble organic nitrogen, and effected a complete reduction of the nitrate under similar conditions; B. pyocyaneus produced 9.9 mg. of insoluble organic nitrogen, with the complete reduction of the nitrate. With cellulose and asparagine B. New Jersey produced 1.6 mg. of insoluble organic nitrogen, without completely reducing the nitrate, while B. pyocyaneus produced 6.7 mg. of insoluble organic nitrogen and destroyed the nitrate completely. With dextrine and asparagine B. New Jersey effected complete denitrification, with the formation of 1.3 mg. of insoluble organic nitrogen, while B. pyocyaneus produced 4.5 mg. under the same conditions, but did not destroy the nitrate completely. Similar relations hold true in the case of starch and asparagine—B. pyocyaneus producing more insoluble organic nitrogen and exerting a more limited denitrifying action. In the case of asparagine and glucose a complete reduction of the nitrate was effected in both cases, with the production of the same amount of insoluble organic nitrogen. This indicates that glucose is a very suitable substance for B. pyocyaneus for the destruction of nitrate. No growth at all took place in asparagine and lactose inoculated with B. New Jersey, while the same solution inoculated with B. pyocyaneus there was abundant growth. From other experiments it was also found that while the salts of citric acid are a very suitable source of carbon for B. New Jersey, and the salts of lactic acid not as suitable, B. pyocyaneus takes very kindly to the latter. B. New Jersey produced no growth in maltose and asparagine; B.

pyocyaneus produced 8 mg. of insoluble organic nitrogen, and effected a complete destruction of the nitrates.

These facts again prove that the development of the denitrifying bacteria is not necessarily proportionate to their denitrifying power. On the one hand, there may be considerable growth and development with scarcely any reduction of the nitrate present in the solution; on the other hand, there may be a comparatively limited growth, accompanied by the complete reduction of the nitrate. Salzmann has noticed[1] a similar relation of the bacteria to the organic substance serving as the source of carbon. Working with B. Stutzeri, he found that certain carbon compounds like oxalic acid—isobutyl, isoamyl and *amylalcohol—while they allowed the growth of the bacteria,* did not enable the latter to carry the reduction farther than the nitrite stage. In other cases B. Stutzeri produced more or less growth without causing denitrification, this being true of solutions which contained formic, oxalic or saccharic acid, glucose, arabinose, lactose, maltose, inulin, xylan or uric acid.

Still another experiment, to study the comparative value of succinic, malic and tartaric acid as a source of carbon, was arranged. This series was of particular interest, because there is a gradual transition here from the dibasic, succinic acid to the dioxy-dibasic tartaric acid, as follows:

```
   H
   |
H—C—COOH
   |          Succinic acid.
H—C—COOH
   |
   H

   H
   |
HO—C—COOH
   |          Malic acid.
 H—C—COOH
   |
   H

   H
   |
HO—C—COOH
   |          Tartaric acid.
HO—C—COOH
   |
   H
```

[1] Dissertation, Königsberg (1901), Abstr. in Centr. f. Bact., part II., vol VIII., p. 249.

Three organisms were used for inoculation. and namely, B. New Jersey, B. coli and B. subtilis, and the experiment was arranged in the following order:

No.									
1.	Inorganic	solution	+	succinic acid, sterile.					
2.	"	"	+	"	"	inoc., B. New Jersey.			
3.	"	"	+	"	"	"		"	"
4.	"	"	+	malic acid, sterile.					
5.	"	"	+	"	"	inoc.,		"	"
6.	"	"	+	"	"	"		"	"
7.	"	"	+	tartaric acid, sterile					
8.	"	"	+	"	"	inoc.,		"	"
9.	"	"	+	"	"	"		"	"
10.	"	"	+	succinic	"	inoc , B. coli.			
11.	"	"	+	"	"	"	"		
12.	"	"	+	malic acid,		"	"		
13.	"	"	+	"	"	"	"		
14.	"	"	+	tartaric acid,		"	"		
15.	"	"	+	"	"	"	"		
16.	"	"	+	succinic	"	"	B. subtilis.		
17.	"	"	+	"	"	"	"		
18.	"	"	+	malic	"	"	"		
19.	"	"	+	"	"	"	"		
20.	"	"	+	tartaric	"	"	"		
21.	"	"	+	"	"	"	"		

The inorganic solution was made up as in the above experiments, calcium carbonate was added in each case and the alkalinity was made —.1, to phenolphtaleine. The organic acids, added at the rate of 5 gr. per liter, were ultimately presented to the bacteria as the corresponding sodium salts. Potasium nitrate was used as the only source of nitrogen, at the rate of 2 gr. per liter. In each flask there were 200 cc. of solution. After inoculation the cultures were kept in the incubator at 28° to 30° C. In about four weeks after inoculation the following observation was made:

1	Clear.	12	Somewhat cloudy.
2	"	13	" "
3	"	14	Clear.
4	"	15	"
5	"	16	"
6	Turbid, bubbles.	17	"
7	Clear.	18	"
8	"	19	"
9	"	20	"
10	"	21	"
11	"		

After four months the appearance of the respective flasks was not changed much. Five and 6 showed large bubbles; 10 and 11, 12 and 13, while they showed no bubbles, indicated considerable growth. The flasks were then sterilized in the autoclave and filtered. The nitrogen determinations in the material on the filter corresponded with the appearance of the cultures. The amounts of insoluble organic nitrogen found were in—

5............1.7 mg.	10............1.6 mg.	12..............0.4 mg.
6............1.4 "	11. ....1.7 "	13..............1.8 "

In the other flasks there was no apparent growth, and no insoluble organic nitrogen was found. Of the three acids presented to B. New Jersey, malic acid proved suitable for complete denitrification, while the other two were not available. B. coli could make use of both succinic and malic acid for its development, yet there was not in any of these cases a complete destruction of the nitrate, but only a reduction to nitrate, quanitative determinations showing more than 80 per cent. of the original nitrate nitrogen converted into nitrite nitrogen. The amounts of insoluble organic nitrogen formed hy B. coli show some discrepancies. Thus, in 12 we find only .42 mg. of insoluble organic nitrogen, while in the parallel, 13, we find 1.8 mg. Apparently, we have to deal here with cultural peculiarities not thoroughly understood. B. snbtilis showed no growth at all and no production of insoluble organic nitrogen. Here we have three organisms, one of which developed in the presence of malic acid, with the complete destruction of the nitrate; another developed both in malic and succinic acid, with the far-reaching reduction of nitrate to nitrite, and the third organism, which could not derive its energy from any of the three organic acids.

A close insight into the nature of denitrification would enable us to account for these peculiarities. As the matter stands at present the various explanations which have been offered do not account for all of the phenomena observed. It is true that the students of the subject agree almost unanimously that the partial or complete exclusion of oxygen favors denitrification, and that a thorough aeration retards it, or stops it completely; yet this knowledge does not help us to understand how the oxygen is withdrawn from the nitrate. It would not be out of place, perhaps, to state here that in the literature of denitrification, some cases, at least, are known where thorough aeration rather favors than retards denitrification. Such an observation

was made by Stoklasa[1] in regard to B. megatherium, which caused a very rapid reduction of nitrite in solutions thoroughly aerated and containing either xylose or arabinose as the source of energy. In twelve days, at 28° C., there was a loss of 59.89 per cent. of the nitrogen originally present in the solution. Apart from this fact and a few others the evidence is all in favor of the view stated above, namely, that the partial or complete exclusion of oxygen favors the reduction of nitrates.

It has been found that in solutions containing the nitrogen in some other form than nitrate, the denitrifying bacteria develop readily when in contact with the air, but that they do not develop when the air or oxygen is excluded. It has been found that in similar solutions containing nitrate the bacteria develop and destroy the nitrate with the evolution of free nitrogen, even when the air or oxygen is excluded; in fact, the growth of the denitrifying organisms is favored by anaerobic conditions of the experiment. It has been found, moreover, that the denitrifying bacteria can grow in solutions containing nitrate without reducing the latter, provided that air or oxygen is passed through the solution, or, better still, when the inoculated medium is spread out in a very thin layer, thus presenting a large surface to the oxygen.[2] All these facts indicate that it is the oxygen of the nitrate which plays the important part in their reduction. Additional evidence in favor of this view is brought forward by Weissenberg,[3] who believes that his contention is proved by the following simple experiment: Four 10 cc. lots of bouillon were prepared, part of them containing .25 per cent. of sodium nitrite, inoculated with B. pyocyaneus and kept for three days at 37° C.

(*a*) Tube with 10 cc. of bouillon and without nitrite, anaerobic. Result, no growth, or, at best, very insignificant.

(*b*) Tube with 10 cc. of bouillon, containing nitrite, anaerobic. Result, excellent growth, active fermentation. Disappearance of the nitrite.

(*c*) Two hundred cc. flask, containing only 10 cc. of nitrite bouillon, aerobic. Result, excellent growth but no fermentation. Nitrite remaining.

(*d*) As in *c*, but anaerobic. Result, excellent growth and fermentation. Disappearance of the nitrite.

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[1] Centr. f. Bact., part II., vol. IV. (1898), p. 287.

[2] Lemmermann, l. c., pp. 37–53.

[3] Centr. f. Bact., vol. VIII. (1902), p. 166.

Maassen found that the addition of chlorate diminishes denitrification without otherwise influencing the growth of the denitrifying bacteria, but that the reduction of the nitrate to nitrate still takes place. This, again, is in line with the claim of Weissenberg[1] that the reduction of nitrate to nitrite, and the reduction of nitrite with the evolution of free nitrogen, are entirely distinct processes. B. Actinopelte, isolated by Baur,[2] shows some striking peculiarities. It is not capable of destroying nitrites in pure nitrite bouillon, but is capable of denitrification when growing together with other bacteria, or when growing in solutions where other bacteria had been growing and had been killed by sterilization, or when certain carbohydrates were added to the solution. When recently isolated B. Actinopelte could destroy nitrates, as well as nitrites, with the evolution of free nitrogen, but it gradually lost the power of reducing nitrates to nitrites, although it still retained the power (to a very limited extent) to destroy nitrites. Baur also thinks that the nitrites are destroyed by B. Actinopelte, because of its oxygen requirements. This organism can develop under anaerobic conditions, but grows better in nitrite containing media than in nitrite free media. The access of oxygen favors the denitrification, and this is also true of B. lobatum, another organism isolated by Baur. Evidently we have to deal here with individual peculiarities, which render the problem more complicated. Unfortunately the original article is not at hand, and from the abstract referred to it would seem that the author contradicts himself. On the one hand, we are told that the nirite is destroyed because of the oxygen requirements of the bacteria, and on the other that the access of oxygen favors denitrification—that is, the destruction of nitrite. The greater amount of experimental evidence, as noted above, indicates that the free access of oxygen diminishes the destruction of the nitrates, which is not in accord with Baur's observations.

The Transformation of the Nitrogen in Nitrate Bouillon.

The organisms employed in this experiment were B. coli commune, B. cholera suis, proteus vulgaris, B. subtilis and B. pyocyaneus, obtained from the bacteriological laboratories at Cornell University. In each case inoculation was made into tubes containing 10 cc. of sterile

[1] Lemmermann, l. c., p. 38.

[2] Centr. f. Bact., part II., vol. VIII. (1902), p. 538.

nitrate bouillon. The experiment lasted twenty-eight days, and its arrangement and results were as follows:

	Insoluble Organic N.	Ammonia N.	Nitrate N.	Total N.
1. Sterile	......	......	1.020 mg.	23.88 mg.
2. B. coli	.401 mg.	1.842 mg.	.199 "	21.02 "
3. B. coli	.401 "	1.083 "	.219 "	18.38 "
4. B. cholera suis	......	......	.205 "	19.48 "
5. B. cholera suis	......	......	.205 "	19.48 "
6. Proteus vulgaris	1.129 "	4.011 "	.121 "	18.71 "
7. Proteus vulgaris	.976 "	4.335 "	.141 "	18.38 "
8. B. subtilis	.687 "	4.662 "	Lost.	18.93 "
9. B. subtilis	.542 "	4.986 "	1.030 "	19.26 "
10. B. pyocyaneus	1.518 "	3.684 "	.150 "	15.96 "
11. B pyocyaneus	1.012 "	4.011 "	.135 "	15.95 "

The amounts of insoluble organic nitrogen produced by the different bacteria were variable, the greater quantity being formed by B. pyocyaneus; B. cholera suis produced very slight growth, with practically no insoluble organic nitrogen. The amount of insoluble organic nitrogen formed by B. coli was comparatively small. In the case of ammonia the relations are somewhat different. The greatest quantity was found in the cultures of B. subtilis and the next greatest in the cultures of proteus vulgaris. The ammonia found in the cultures of B. cholera suis was practically nil. It will be noticed that the nitrates were diminished in amount in every case except in that of B. subtilis, where the amount found was nearly the same as that found in the sterile tube. This is rather strange, in view of the fact that B. subtilis had been reported by several investigators as capable of reducing nitrates. Comparing the quantities of total nitrogen as found by analysis, it will be noticed that there was less nitrogen present at the end of the experiment than was found in the sterile tube. The greatest loss was caused by B. pyocyaneus, almost 8 mg. out of the 23.83 mg. orginally present. B. cholera suis, although it produced but slight growth, cansed, nevertheless, a loss of nitrogen. The parallels in B. coli showed considerable differences; in one of them there was much more ammonia found than in the other, and the total nitrogen found was also greater in amount. Proteus vulgaris caused a smaller loss of nitrogen than did B. subtilis, although the differences are not great. In view of the comparatively large amounts of ammonia formed, it would seem that the losses of nitrogen may have occurred by the volatilization of the ammonia rather than by the evo-

lution of free nitrogen from the nitrate. This belief is strengthened by the fact that the largest quantity of ammonia was produced by B. subtilis, and yet there was no reduction of the nitrate in this case.

In a similar experiment, also, extending through twenty-eight days, the following results were obtained:

	Insoluble Organic N.	Ammonia N.	Nitrate N.	Total N.
1. Sterile...............	......	......	1.00 mg.	22.28 mg.
2. "	......	......	.95 "	22.28 "
3. B. coli...............	1.30 mg.	1.65 mg.	.16 "	17.83 "
4. B. cholera suis.....	.64 "	.64 "	.16 "	17.83 "
5. B. subtilis...........	...... "	3.18 "	.95 "	18.47 "
6. B. pyocyaneus.....	1.11 "	2.55 "	...... "	14.60 "
7. Proteus vulgaris..	1.02 "	3.44 "	.14 "	15.92 "

Also here the greatest loss of nitrogen was caused by B. pyocyaneus, although the amount of insoluble organic formed was not as great as formed by B. coli. Practically no insoluble organic nitrogen was formed by B. subtilis, although it produced growth with the formation of the next greatest amount of ammonia. The nitrate was not affected, apparently, also, in this case. The loss of nitrogen caused by B. pyocyaneus was very considerable, more than one-third of the original amount having disappeared. Proteus vulgaris also caused a large loss of nitrogen, and it produced 3.44 mg. of ammonia, an even greater amount than that formed by B. subtilis. There was a diminution of nitrate in every case. B. pyocyaneus caused a complete disappearance of the nitrates; in the other cases most of it had vanished from whatever cause, with the exception already noted.

The Reduction of Different Nitrates by B. New Jersey var. and B. Pyocyaneus.

In order to determine the relative denitrification of the alkali and alkaline earth nitrates, an artificial solution was made up containing $K_2H\ PO_4$, $Mg.\ SO_4$, $CaCl_2$, $Fe_2\ Cl_6$, in the same quantities as in the other experiments. Calcium carbonate was also added to each flask, at the rate of 5 gr. per sample. The arrangement of the experiment was:

1.	100 cc.	of solution	containing	.2 gr. KNO_3		—sterile.
2.	"	"	"	"	"	— "
3.	"	"	"	"	"	—B. New Jersey var.
4.	"	"	"	"	"	—B. pyocyaneus.
5.	"	"	"	.168 gr. $NaNO_3$		—B. New Jersey var.
6.	"	"	"	"	"	—B. pyocyaneus.
7.	"	"	"	.079 gr. NH_4NO_3		—B. New Jersey var.
8.	"	"	"	"	"	—B. pyocyaneus.
9.	"	"	"	.146 gr. $Mg(NO_3)_2$		—B. New Jersey var.
10.	"	"	"	"	"	—B. pyocyaneus.
11.	"	"	"	.260 gr. $Ba(NO_3)_2$		—B. New Jersey var.
12.	"	"	"	"	"	—B. pyocyaneus.
13.	"	"	"	.211 gr. $Sr(NO_3)_2$		—B. New Jersey var.
14.	"	"	"	"	"	—B. pyocyaneus.

The samples were sterilized in the autoclave, inoculated with the corresponding bacteria and kept at room temperature. In four days the following observations were made:

1. Clear, no growth.
2. " " "
3. Cloudy, sediment.
4. " " whitish, brittle layer on surface.
5. Very slightly cloudy, flaky precipitate.
6. Cloudy, heavy, whitish, brittle layer.
7. Moderately turbid, white patches on surface.
8. Cloudy, whitish, brittle layer, some large bubbles.
9. Moderately turbid, surface layer irregular in thickness, flaky deposit.
10. Heavy, white brittle layer, cloudy flakes.
11. Moderately turbid, copious, flaky deposit.
12. Bubbles on surface, whitish layer, liquid yellowish, turbid.
13. As in 11.
14. As in 12.

In the presence of strontium and barium nitrate, B. pyocyaneus produced the characteristic golden yellow color, while it failed to produce that in the presence of the other nitrates. It was noticed in other cultures that B. pyocyaneus readily produces the pigment in bouillon, but does not do so readily in artificial solutions, and the above cases are the only exceptions noted. B. pyocyaneus also formed a brittle layer on surface, while B. New Jersey failed to produce any layer or pellicle. After eighteen days the different cultures were tested with diphenylamine for nitrates and nitrites, with negative results, excepting, of course, 1 and 2, which had been kept sterile, and therefore unchanged. The analysis of the insoluble organic

nitrogen formed was carried out as in the other experiments. The total nitrogen in the filtrate was also determined in each case. The results obtained were as follows:

	Insoluble Organic N.	N. in Filtrate.	Total N.
1	......	27.0 mg.	27.0 mg.
2	......	27.0 "	27.0 "
3	1.89 mg.	6.09 "	7.98 "
4	2.04 "	10.29 "	12.33 "
5	2 34 "	4.14 "	6.48 "
6	2.49 "	9.66 "	12.15 "
7	4.59 "	7 07 "	11.66 "
8	3.09 "	10.86 "	13.95 "
9	1.74 "	2 34 "	4.08 "
10	2.94 "	6.66 "	9.60 "
11	1.74 "	2.94 "	4.68 "
12	3.99 "	8.49 "	12.48 "
13	3.66 "	2 94 "	6.60 "
14	4.26 "	9.39 "	13.65 ".

The amount of insoluble organic nitrogen produced by B. pyocyaneus was in every case but one greater than that produced by B. New Jersey var. This agrees with the experiments reported above, and again indicates that the losses of nitrogen caused by the growth of B. pyocyaneus are not as great as those caused by the growth of B. New Jersey or of B. New Jersey var. in solutions containing nitrates. And the same conclusions must be drawn again, and namely, that either a greater number of B. pyocyaneus is required to reduce a given quantity of nitrate or that the body substance of B. New Jersey is poorer in nitrogen. Of course, one other conclusion is possible, and namely, that in its metabolism B. pyocyaneus produces a greater quantity of insoluble secondary products rich in nitrogen. The one exception noted above, where B. New Jersey var. produced a greater amount of insoluble organic nitrogen than was produced by B. pyocyaneus, was in the solution where ammonium nitrate was used. In this case not all of the nitrogen was in the form of nitrate, and the conditions were somewhat different. The greatest amount of insoluble organic nitrogen formed by B. pyocyaneus was in the solution containing strontium nitrate, the amount prduced in the solution containing barium nitrate being but slightly less. Excepting sample 7, where ammonium nitrate was employed also, B. New Jersey var. produced the greatest amount of insoluble organic nitrogen in the solution containing strontium nitrate, while barium nitrate

was by no means as favorable. Comparing potassium and sodium nitrate (*equivalent amounts of nitrogen were used in the experiment*) we find a greater production of insoluble organic nitrogen from the latter, both by B. New Jersey var. and B. pyocyaneus, and magnesium nitrate produced the least amount of insoluble organic nitrogen in the case of both B. New Jersey var. and B. pyocyaneus. Looking at it from another standpoint, it appears that the complete denitrification of magnesium nitrate required the activity of fewer organisms than was true in the case of any of the other nitrates.

Comparing the amounts of nitrogen found in the filtrate—that is, as soluble organic nitrogen and ammonia—we find that also here the losses caused by B. pyocyaneus were smaller. The greatest amount of nitrogen found here, both in the case of B. New Jersey and B. pyocyaneus, was in the solution containing ammonium nitrate. This is as it should be, since part of the nitrogen was contained in the substance as ammonia, and the latter would not be affected in denitrification proper to such an extent. The least amount of soluble organic and ammonia found was in the solution where magnesium nitrate was used. In the solution inoculated with B. pyocyaneus there was, however, a greater amount of nitrogen found than in the solution inoculated with B. New Jersey var. Without exception the amounts of soluble organic and ammonia nitrogen found in the different solutions was greater where B. pyocyaneus was used for inoculation than where B. New Jersey var. was used. Comparing potassium and sodium nitrate we find that in this case more nitrogen was found in the solution where the former was used, that applying to B. New Jersey var. as well as to B. pyocyaneus. In the solutions containing barium and strontium nitrate, respectively, and inoculated with B. New Jersey var., the amounts of nitrogen found in the solution at the end of the experiments were the same. In the case of B. pyocyaneus, however, the amount of nitrogen found in the strontium nitrate solution was greater. Comparing the total amounts of nitrogen recovered we find that in every case B. pyocyaneus caused a slighter loss. On the whole, every nitrate tried here could be used by both organisms when no other source of nitrogen was at their disposal.

Also, Sewerin[1] observed that potassium and sodium nitrate are reduced in an unequal degree. B. pyocyaneus, according to him, reduces a greater quantity of KNO_3 than of $NaNO_3$. Salzmann[2] observed that

[1] Centr. f. Bact., part II., vol. III. (1897), p. 554.

[2] L. c., p. 349.

B. Hartlebi could reduce barium as well as lead nitrate, while B. Stutzeri could reduce barium nitrate to barium nitrite only, and that lead nitrate acted as a poison towards B. Stutzeri. Evidently we have to deal here with variations in the reducing power of the different organisms. In the case of B. Hartlebi, for instance, Salzmann found that this organism could reduce potassium chlorate to potassium chloride and potassium ferricyanide to potassium ferrocyanide, while B. Stutzeri remained indifferent in this respect. The intensity of the reduction determines the amount of the intermediate products of reduction which appear. Thus the reduction of barium nitrate to barium nitrite by B. Stutzeri merely shows that its reducing power is more limited than that of B. Hartlebi. When the intensity of denitrification is diminished the intermediate products, nitrite and ammonia, appear. This is best illustrated by the behavior of B. coli in solutions containing nitrate. It is well known that B. coli has the power of reducing nitrate to nitrite. An experiment by Wolf proves[1] that B. coli can also reduce nitrates completely, provided that the concentration is slight. In this particular experiment quantities of KNO_3 up to .08 per cent. were reduced with the evolution of nitrogen. B. typhosus reduced quantities of KNO_3 up to .09 per cent., B. Fitzianus up to .18 per cent., a bacillus resembling B. subtilis up to .22 per cent. Sewerin found[2] that out of nine organisms which reduced nitrate to nitrite in a .3 per cent. solution, two produced a complete reduction of the nitrate in a .1 per cent. solution and four more were capable of completely reducing the nitrate in a .05 per cent. solution of KNO_3. It thus appears that, in many cases at least, bacteria differ as to their power of denitrification in degree rather than in kind. At the same time there are bacteria incapable of reducing nitrates, while they can readily destroy nitrites with the evolution of free nitrogen. This is true of B. denitrificans, as proved by Weissenberg,[3] and also of Bacillus 21, isolated in this laboratory. Lemmermann[4] objects to Weissenberg's conclusions and brings forward Künnemann's claim that B. denitrificans is incapable by itself of destroying not only nitrates, but also nitrites. There is no doubt, however, that Bacillus 21 cannot reduce nitrates when alone, and it is also quite certain that it can destroy nitrites with the evolution

[1] Hygien. Rundschau, vol. IX. (1899), quoted by Lemmermann, l. c., p. 36.
[2] Centr. f. Bact., part II., vol. III., p. 506.
[3] Centr. f. Bact., part II., vol. IV. (1898), p. 42.
[4] L. c., p. 39.

of free nitrogen when growing alone. If, as Weissenberg asserts, the reduction of nitrate to nitrite and the reduction of nitrite itself are distinct processes, then we must assume that B. coli and other bacteria possess the power of reducing nitrate to nitrite in an ample degree, and that, to a limited extent, they also possess the power of reducing nitrite with the evolution of free nitrogen. According to him the *reduction of nitrite with the evolution of free nitrogen is due to the* withdrawing of the oxygen by the bacterial cell, and he claims to prove this by the fact that with an abundant supply of oxygen in the liquid denitrification proper is either stopped entirely or is materially diminished, while the reduction of nitrate to nitrite may take place. However, it was already pointed out elsewhere that cases are known where the reduction of the nitrate is favored, rather than retarded, by thorough aeration. But, if denitrification consists of two distinct processes, the presence of nitrite should be made evident when tested with the proper reagents during the reduction. As a matter of fact there is some conflicting evidence at hand. Sewerin[1] could detect no nitrite reaction during the entire course of denitrification by one of the bacteria isolated by him, and Künnemann[2] could detect no nitrite in the entire course of denitrification by an organism resembling B. denitrificans II. (B. Stutzeri, Lehmann-Neumann).

The Fixation of Nitrogen by Denitrifying Bacteria.

The fact that certain soil bacteria are capable of fixing atmospheric nitrogen has been known for some time. The work of Berthelot, Kruger, Winogradsky, Beijerinck, Caron and others shows that such bacteria do exist.[3] Stoklasa[4] and Vitek have raised the question whether there is not something in common between the fixation of atmospheric nitrogen on the one hand and the destruction of nitrates with the evolution of free nitrogen on the other. They base their belief on the fact that B. ellenbachensis, which they regard as identical with B. megatherium, can fix atmospheric nitrogen under certain conditions, while under different conditions it reduces nitrates. An observation of Hiltner's[5] also tends to lend credence to this view.

[1] Centr. f. Bact, part II., vol. III. (1897), p. 555.
[2] Landw. Vers. Stat., 50 (1898), 82.
[3] See Jacobitz, Centr. f. Bact., part II., vol. VII. (1901), pp. 783, 833, 876.
[4] Centr. f. Bact., part II., vol. VII. (1901), p. 257.
[5] Centr. f. Bact., part II., vol. IX. (1902), p. 73, abstract.

He found that in the soils inoculated with denitrifying bacteria the yields of plant substance were greater than where the soils were kept sterile. This is not a direct proof, of course, that denitrifying bacteria actually add nitrogen to the soil; the increased yield may also be due to the greater amount of the inert soil nitrogen made soluble by the bacteria, and therefore available to the growing plants. Nevertheless, positive evidence does not exist where there may not be conditions in the soil which would favor the fixation of nitrogen by B. pyocyaneus or other denitrifying bacteria occurring in the soil. The recent work of Winogradsky[1] and that of Beijerinck and van Delden[2] are of great interest in giving us a conception, at least, of the extent and the importance of the nitrogen-fixing bacteria living in arable soils. In this laboratory, also, a considerable amount of work has been done in the study of soil bacteria and their relation to the free nitrogen of the atmosphere. The work is, however, still considered incomplete, and its publication will be delayed until next year.

At the same time some work has been done in order to determine the ability of B. pyocyaneus and of other denitrifying bacteria to fix atmospheric nitrogen. These studies, being in line with other work on the physiology of denitrifying bacteria, are therefore reported here. Since, as has been shown, the growth of B. pyocyaneus in solutions containing considerable amounts of combined nitrogen results in the loss of a greater or slighter proportion of it, the solutions intended for the study of the possible nitrogen-fixing power of this organism contained little nitrogen or none at all. There seems to be some analogy here with the fixation of atmospheric nitrogen by legumes, *the fixation in this case taking place only when the amount of* the soil nitrogen is insufficient for the needs of the plant. Something similar is probably true of the nitrogen-fixing bacteria. It is possible, of course, that some of these will grow in nitrogen-free solutions by preference, and Winogradsky's Clostridium Pasterianum actually does fix considerable quantities of atmospheric nitrogen in nitrogen-free solution. On the other hand, Beijerinck found[3] that the aerobic organisms isolated by him fix greater quantities of atmospheric nitrogen when they have small quantities of combined nitrogen present in the solution at the beginning of the experiment. The work in this labora-

[1] **Centr. f. Bact., part II., vol. IX., (1902), p. 43.**
[2] **Centr. f. Bact., part II., vol. IX. (1902), p. 3.**
[3] **L. c.**

tory also shows that the presence of a little combined nitrogen at the beginning of the experiment favors the fixation of atmospheric nitrogen.

The solutions used in the study of the nitrogen-fixing power of B. pyocyaneus contained traces of nitrogen, added in the form of peptone. The inorganic solution was made up as in the other experiments. For comparison with B. pyocyaneus there were also used B. New Jersey and B. megatherium, the latter having been found to possess some nitrogen-fixing power. As the source of carbon citric, lactic, a tartaric acid was used at the rate of 20 gr. per liter; 100 cc. of solution was employed in each case. The reaction was neutral to faintly alkaline. In each flask there was also added .5 gr. of calcium carbonate. The following was the arrangement of the experiment:

B. NEW JERSEY.

1. Inorganic solution, .1 mg. peptone, 2 gr. citric acid—Sterile.
2. " " " " " " " Inoculated.
3. " " " " " " " "
4. " " " " " lactic " Sterile.
5. " " " " " " " Inoculated.
6. " " " " " " " "
7. " " " " " tartaric acid—Sterile.
8. " " " " " " " Inoculated.
9. " " " " " " " "

B. MEGATHERIUM.

10. Inorganic solution, .1 mg. peptone, 2 gr. citric acid—Inoculated.
11. " " " " " " " "
12. " " " " " lactic " "
13. " " " " " " " "
14. " " " " " tartaric acid "
15. " " " " " " " "

B. PYOCYANEUS.

16. Inorganic solution, .1 mg. peptone, 2 gr. citric acid—Inoculated.
17. " " " " " " " "
18. " " " " " lactic " "
19. " " " " " " " "
20. " " " " " tartaric acid "
21. " " " " " " " "

B. SUBTILIS.

22. Inorganic solution, .1 mg. peptone, 2 gr. citric acid—Inoculated.
23. " " " " " " " "
24. " " " " " lactic " "
25. " " " " " " " "
26. " " " " " tartaric acid "
27. " " " " " " " "

Four days after inoculation 2 and 3 showed distinct turbidity and growth, 16 was coludy, as was 21. The rest were all clear. In seven days 2 and 3 were turbid, 16 and 17 turbid, 18 and 19 cloudy, 20 and 21 turbid. The rest were all clear. In two weeks 2, 3, 16, 17, 18, 19, 20 and 21 were turbid; the others all clear, with no signs of growth.

At tbe end of three months 2 and 3 were turbid, and 16, 17, 18 and 19 turbid, with membrane on surface. The others appeared clear. The cultures were then sterilized in the autoclave, the solutions filtered and the nitrogen determined, both in the filtrate and in the filtered residue. After substracting the blanks the following amounts were obtained:

NITROGEN FOUND.

	Insol. Organic.	Soluble Organic.	Total.
1	....	....	....
2	Traces.	Traces.	Traces.
3	.15 mg.	.14 mg.	.29 mg.
4 to 15 inclusive	....	....	....
16	.14 "	.35 "	.49 "
17	.14 "	.39 "	.53 "
18	.44 "	.08 "	.52 "
19	.44 "	.24 "	.68 "
20 to 27 inclusive	....	....	....

It will be seen that B. New Jersey produced a slight growth in citric acid, but the nitrogen found was not above the limit of error. No growth was observed, either in the lactic or tartaric acid, and no nitrogen was found. B. megatherium and B. subtilis showed no growth, and no nitrogen was found in the solutions. B. pyocyaneus made considerable growth, showing a gain in the lactic acid of more that .5 mg. of nitrogen. To be sure, the gain was slight, and it may be claimed that it is within the limits of error. Nevertheless, there is no doubt as to the results, for the work was carefully done and the duplicates agreed. Here it appears again that of the three organic acids employed B. New Jersey found the citric acid the most suitable, while B. pyocyaneus found the lactic acid more suitable, although it made some growth, also, in critic acid. In order to prove the fact with certainty, and namely, that B. pyocyaneus can obtain small quantities of nitrogen from the air, the experiment was repeated.

Some modifications were adopted here, however; instead of 100 cc. of solution, 200 cc. were taken, and only citric and lactic acid were

used, each at the rate of 5 gr. per liter. The inorganic solution was of the same composition, and .5 gr. of calcium carbonate were also added in each case. The solutions were made faintly alkaline to phenolphytaleine by the addition of sodium hydroxide. Flasks of varying sizes were used, so as to expose a greater or smaller surface. Flasks 1, 2, 3 and 4 were of 500 cc. capacity and 5, 6, 7 and 8 of 1,000 cc. capacity, 9 and 10 in large, flat dishes. The quantity of peptone added was also variable, as shown in the accompanying tabulation:

1.	Inorganic	solution,	1 gr.	lactic	acid	.1 mg. peptone.
2.	"	"	1 "	citric	"	.1 " "
3.	"	"	1 "	lactic	"	.5 " "
4.	"	"	1 "	citric	"	.5 " "
5.	"	"	1 "	lactic	"	.1 " "
6.	"	"	1 "	citric	"	.1 " "
7.	"	"	1 "	lactic	"	.5 " "
8.	"	"	1 "	citric	"	.5 " "
9.	"	"	1 "	lactic	"	.1 " "
10.	"	"	1 "	citric	"	.1 " "
11.	"	"	1 "	lactic	"	.5 " "
12.	"	"	1 "	citric	"	.5 " "

All except 11 and 12 were inoculated with B. pyocyaneus.

At the end of six weeks the following observations were made:

1. Cloudy, some growth.
2. Clear, apparently no growth.
3. Cloudy, somewhat more growth than in 1.
4. Clear, no apparent growth.
5. Cloudy, growth more abundant than in 3.
6. Slight cloudiness.
7. Cloudy, growth as in 5.
8. Slight cloudiness, more pronounced than in 6.
9. Probably growth.
10. " "
11. Clear.
12. "

These observations indicated that lactic acid was a more suitable medium than citric acid, for whatever growth was made by B. pyocyaneus. The extent of surface had an evident influence on the growth, for, while there was no apparent growth with citric acid in 2 or 4, there was some growth in 6 and 8. On analysis, the following results were obtained:

	Insoluble Nitrogen.	Soluble Nitrogen.	Total Nitrogen.		Insoluble Nitrogen.	Soluble Nitrogen.	Total Nitrogen.
1	.15 mg.	....	.15 mg.	7	.60 mg.	....	.60 mg.
2......	....	....	....	8......	.15 "	....	.15 "
3	.30 "	....	.30 "	9	.75 "	.80 mg.	1.55 "
4......	....	....	....	10......	.60 "	.75 "	1 35 "
5	.39 "	....	.39 "	11	....	....	....
6......	....	....	....	12	....	....	....

The fact is here brought out again and placed beyond the shadow of a doubt that B. pyocyaneus were enabled to obtain small quantities of nitrogen not contained in the solution, that this power increased as the surface exposed increased, and that lactic acid served as a far better source of carbon than did citric acid. In fact, there was no evident growth in the citric acid solution contained in the 500 cc. flasks, but there was some growth in the same solution, as it was spread out in a thinner layer in the flat-bottomed, 1,000 cc. flasks. The quantity of peptone added, though containing an unweighable amount of nitrogen, exerted a considerable influence. With an addition of .1 mg. the growth was not as extensive as with .5 mg. Thus, with .1 gm. of peptone in 1, half as much nitrogen was fixed as in 3, where .5 mg. was added to the solution. At the same time, there was even more nitrogen fixed in 8, where only 1 mg. of peptone was added, than there was in 3, where .5 mg. of peptone was added, but where the liquid was shallow and the surface exposed proportionately great, the amount of nitrogen fixed was greater than in 7, where 5 mg. of peptone were added, but where the depth of liquid was greater and the surface area exposed much less. Moreover, in 9 and 10 there were not only greater amounts of nitrogen found as insoluble organic, but also comparatively considerable quantities in the filtrate as soluble organic. This experiment clearly indicates that B. pyocyaneus has the power of fixing small quantities of atmospheric nitrogen; that this fixation is largely influenced by the organic compound used as the source of carbon and of energy. Lactic acid is decidedly superior to citric acid, but with thorough aeration, also, the latter can be used for the purpose. Fnrthermore, the amount of nitrogen fixed is influenced by the depth of the liquid layer, and that, everything being equal, the greater the surface exposed the greater the amount of nitrogen fixed. It is possible that, under still different conditions, not yet tried, even a greater fixation may be obtained. Similar experiments with the symbiotic B. 20 and B. 21 have been tried, and also others

with B. pyocyaneus. In the former case, small quantities were undoubtedly fixed, quantities too small to make the results decisive; in the latter case the results obtained were similar to those stated above, and need not be given here.

In how far this fixation is a factor in our arable soils yet remains to be determined; but from the theoretical standpoint the results reported here are of great interest, in that they show how the same organism may at times exert a destructive effect on combined nitrogen, and at other times it may actually add to the world's store of combined nitrogen. It is hoped that further experiments will be made, in order to shed more light on these physiological processes.

The Nitrogen Content of Some New Jersey Soils and Subsoils.

These soils and subsoils were collected in the fall of 1901, and most of them are typical South Jersey soils. The subsoils were numbered to agree with the corresponding soils. Samples IX. and X., as well as the corresponding subsoils, obtained in the vicinity of Bridgeton, were lost in transit and could not be recovered. The nitrogen content reduced to the water-free basis, as well as partial mechanical analysis of the different samples, are given here.

SOIL III.

Obtained from the farm of C. C. Hulsart, Matawan. A rather light, sandy loam, underlaid by a yellowish sand, and that, in turn, by clay. It is a well-drained soil, well adapted for early truck.

SOIL IV.

This sample was obtained from the farm of John H. Denise, Freehold. This is a deep, heavy loam, famed for its great crops of potatoes, and situated in the marl area.

It will be seen that this subsoil is a fine-grained soil of great water-holding power. The sample of soil was taken to a depth of twelve inches, of the subsoil to a further depth of sixteen to eighteen inches.

SOIL V.

Obtained from the farm of A. P. Arnold, Vineland. This is a very light, sandy soil, underlaid by coarse sand or sandy clay; a warm and well-drained soil, but poor in organic matter, and but five to six inches deep. Excellent crops of sweet potatoes are raised on this soil.

SOIL VI.

Obtained from the farm of G. A. Mitchell, Vineland. This is somewhat heavier than soil V., is deeper and underlaid by a gravelly or clayey subsoil. The crops raised are principally sweet potatoes, early truck and peaches. Sweet potatoes are grown year after year, with the application of commercial fertilizers. It will be noticed that this is much finer that soil V.

SOIL VII.

Obtained from the farm of H. L. Parkhurst, Hammonton. The soil varies from the sandy type, like the Vineland sweet potato soils, to a heavier, sandy loam. The soil is six to eight inches deep and underlaid by yellow sand to gravelly clay. Hardpan occurs in some places at a depth of two feet. The principal crops raised are peaches, pears and small fruit.

SOIL VIII.

Obtained from farm near Egg Harbor City, through the kindness of V. P. Hoffman. This a very light, sandy soil. On higher ground it is inclined to he gravelly. The subsoil is a yellow sand, gravelly in some places and clayey in others, forming hardpan at a depth of about two feet. The hardpan is underlaid by reddish or whitish clay. Gravel beds also occur in the vicinity. The principal crops raised are berries (particularly blackberries), grapes, etc.

SOIL XI.

Obtained from the farm of J. C. Griscom, Woodbury. The prevailing type is a sandy to a sandy loam and, in low places, clayey. The subsoil varies from a grayish to a yellowish sand, to which varying quantities of clay are admixed. In low places the subsoil is a red clay (brick clay). The principal crops raised are tomatoes, potatoes, corn, sweet potatoes, etc.

SOIL XII.

Obtained from the farm of M. D. Dickinson, Woodstown. This is a heavy loam to a sandy loam soil, with a tenacious clay subsoil. The principal crops raised are tomatoes, potatoes, corn and grass.

It will be seen that this soil is a fine-grained soil, compact and has a great water-holding power.

SOIL XIII.

Obtained from the farm of I. Hurff Weatherby, Swedesboro. This is a sandy soil, with a red, sandy to somewhat clayey subsoil. The country is rolling and considerable variations in the prevailing types of soil occur. A belt of red soil passes through the region and is peculiar in that the sweet potatoes raised on these red soils are darker in color and can be easily distinguished, according to the statement of the local farmers. The principal crops are sweet potatoes, tomatoes, corn and potatoes. Swedesboro is well known as a shipping centre for sweet potatoes.

This is an open, warm soil, and the mechanical analysis clearly shows that it is permeable and easily tilled.

SOIL XIV.

This soil was obtained from the farm of Theodore Brown, Asbury Station. The soil is not unlike that in the immediate vicinity of Swedesboro. The crops raised are sweet potatoes, tomatoes, egg-plants, melons, etc.

SOIL XV.

This soil was obtained from the farm of J. R. Adams, near Clarksboro. This soil is rather heavier than soil XIV., and may be designated a sandy loam, tending to become clayey or gravelly. The red soils already mentioned also crop out here. The crops raised are corn, potatoes, wheat and grass. Truck is also raised extensively; particularly sweet potatoes and tomatoes.

SOIL XVI.

Obtained from the farm of H. D. Culin, Hainesport. This is a light, sandy soil, with a yellowish, sandy subsoil, containing a fair admixture of clay and extending to a depth of two and one-half to three and one-half feet. The subsoil is used for making mouldings in the foundry. The sample was taken from a field where, for a number of years, commercial fertilizers have been used exclusively. On this particular field onion sets had been grown. Truck and corn are raised extensively in the region.

SOIL XVII.

Obtained from the farm of Emmor Roberts, Moorestown. The soil is a heavy loam, with a clayey subsoil. The principal crops raised are corn, grass, potatoes, wheat. The soil is fine-grained, deep and fertile.

SOIL XVIII.

Obtained from the farm of the De Hirsch School, Woodbine. This is a comparatively new soil, having been cleared about seven or eight years ago. It is light, sandy in character, with a sandy-clay subsoil. The crops raised are berries and fruit, and also truck and forage crops.

SOIL XX.

Obtained from the farm of the De Hirsch School, Woodbine. This is a forest soil, taken to a depth of four inches.

	NO. III.		NO IV.		NO. V.		NO. VI.		NO. VII.		NO. VIII.		NO. XI.	
	Soil.	Subsoil.	Soil.	Subsoil.	Soil.	Subsoil.	Soil.	Subsoil.	Soil.	Subsoil.	Soil.	Subsoil.	Soil.	Subsoil.
Particles more than 2 mm. in diameter	% 1.14	% 4.85	% .50	% .20	% 3.50	% 8.90	% 1.45	% 1.65	% 2.50	% 4.80	% 3.60	% 2.85	% 1.05	% 1.75
Particles between 2 and 1 mm. in diameter	.76	.65	.40	.10	9.60	13.00	2.05	2.05	7.20	6.40	5.45	4.10	.95	.65
Particles between 1 and ½ mm. in diameter	9.45	6.95	4.20	1.65	27.65	26.80	10.30	10.40	16.00	16.50	19.50	19.70	7.70	3.55
Particles less than ½ mm. in diameter	88.65	87.55	94.90	98.05	59.29	51.30	86.20	85.90	74.30	72.30	71.45	73.35	90.30	94.05

	NO. XII.		NO. XIII.		NO. XIV.		NO. XV.		NO. XVI.		NO XVII.		NO. XVIII.		NO. XX.
	Soil.	Subsoil.	Soil.	Subsoil.	Soil.	Subsoil.	Soil.	Subsoil.	Soil.	Subsoil.	Soil.	Subsoil.	Soil.	Subsoil.	Soil.
Particles more than 2 mm. in diameter	% .85	% .75	% .75	% .45	% 1.50	% 3.40	% 2.30	% .25	% .20	% .05	% 1.00	% 1.30	% 6.95	% 8.40	% 5.60
Particles between 2 and 1 mm. in diameter	.40	.10	5.60	5.70	5.40	5.75	1.85	.80	1.80	1.50	1.00	.90	11.40	14.60	10.45
Particles between 1 and ½ mm. in diameter	1.40	.60	33.35	36.50	20.80	18.95	20.10	13.05	6.70	4.35	3.15	2.40	19.80	19.90	23.70
Particles less than ½ mm. in diameter	97.35	98.55	60.30	57.35	72.30	71.90	75.75	85.90	91.30	94 10	94.85	95.40	61.85	57.10	60.25

Hygroscopic Moisture, Volatile Matter and Nitrogen in the Different Soils.

Soil.	Nitrogen.	Hygroscopic Moisture.	Loss on Ignition.	Soil.	Nitrogen.	Hygroscopic Moisture.	Loss on Ignition.
I.	.128 %.	1.57 %.	6.10 %.	XI.	.100 %.	.95 %.	4.10 %.
II.	.112 "	1.29 "	5.46 "	XII.	.146 "	1.73 "	7.20 "
III.	.061 "	.77 "	2.93 "	XIII.	.070 "	.50 "	2.68 "
IV.	.125 "	2.28 "	7.23 "	XIV.	.073 "	.79 "	5.11 "
V.	.038 "	.36 "	2.25 "	XV.	.083 "	.92 "	4.49 "
VI.	.055 "	.59 "	3.30 "	XVI.	.039 "	.69 "	2.47 "
VII.	.065 "	.90 "	4.44 "	XVII.	.080 "	.90 "	4.30 "
VIII.	.055 "	.54 "	3.09 "	XVIII.	.080 "	.82 "	5.06 "
				XIX.	.193 "	2.10 "	9.82 "

Soils I. and II. are from the College Farm and soil XIX. is the *surface soil from a field near the Experiment Station building.* It will be noticed that the hygroscopic moisture is greatest in the soils which show the greatest loss on ignition. In all of these soils the loss on ignition is largely due to the organic matter, and hence most of the hygroscopic moisture is held in the different soils by the organic matter. Some of the soils, especially V. and XVI., contain very little organic matter and very little nitrogen; nevertheless, good crops of sweet potatoes are raised on them by the use of commercial fertilizers. The heavier soils, and namely, I., II., IV., XII. and XIX., are rich in nitrogen, show a considerable amount of hygroscopic moisture and also a corresponding loss on ignition. Soil XVII., while heavy and productive, is not as rich in nitrogen as the other heavier soils; in fact, it contains no more nitrogen that the light, sandy soil from Woodbine. The corresponding subsoils, as will be seen from the subjoined table, are poorer in organic matter and in nitrogen than the surface soils, which should be expected, since the greater amount of organic matter tends to accumulate at the surface.

Hygroscopic Moisture, Loss on Ignition, and Nitrogen in the Different Subsoils.

Subsoil.	Nitrogen.	Hygroscopic Moisture.	Loss on Ignition.	Subsoil.	Nitrogen.	Hygroscopic Moisture.	Loss on Ignition.
III.	.017 %.	0.36 %.	1.35 %.	XII.	.042 %.	1.10 %.	3.85 %.
IV.	.039 "	1.99 "	4.69 "	XIII.	.020 "	.37 "	1.59 "
V.	.028 "	.49 "	2.61 "	XIV.	.023 "	.72 "	4.08 "
VI.	.018 "	.88 "	1.80 "	XV.	.034 "	1.05 "	3.82 "
VII.	.024 "	.85 "	3.11 "	XVI.	.024 "	1.26 "	3.22 "
VIII.	.011 "	.19 "	1.06 "	XVII.	.087 "	1.41 "	4.98 "
XI.	.043 "	1.03 "	3.34 "	XVIII.	.034 "	.58 "	2.98 "

The differences between the nitrogen content of the soils and subsoils are very decided. Thus, subsoil IV., representing the second twelve inches, has a nitrogen content of only .039 per cent., while the corresponding soil, representing the upper twelve inches, has a nitrogen content of .125 per cent. Similarly, the hygroscopic moisture in subsoil IV. is 1.99 per cent., as against 2.28 per cent. in the upper twelve inches, and the loss on ignition from the subsoil is 4.69 per cent., as against a loss of 7.23 per cent. from the upper twelve inches. In the lighter, nitrogen-poor soils the differences are not as great. In subsoil V., representing the second eight inches, the nitrogen content is .028 per cent., as against .038 per cent. in the upper eight inches, while the hygroscopic moisture and the loss on ignition are even greater in the subsoil than they are in the upper soil. A comparison of the tables will bring out similar relations in the other soils and subsoils.

REPORT OF THE ASSISTANT IN HORTICULTURE.

REPORT OF THE ASSISTANT IN HORTICULTURE.

The year past has been fully occupied with the detail of the various permanent experiments outlined in previous reports of this department. Any changes or additions made are noted in their respective places.

The usual records of the weather conditions have been made throughout the year, and show the season, particularly the growing season, to have been an exceptional one as regards temperature and rainfall. The early months were comparatively warm months. The monthly mean for March was 4.7 degrees above the average mean for the period covered by our records. The mean temperature for March, April and May averaged 2.2 degrees above the general averages for the same months in preceding years. Accompanying these temperatures was a deficiency of rainfall amounting to a little over an inch per month. The next four months are to be noticed for their low mean temperatures and high rainfall. The mean temperature for June was 1.9 degrees and for August 4 degrees below the normal, with the average for the four months 3 degrees below the normal. The rainfall for this period averaged .86 inch per month above the normal. Including October the excess above the normal rainfall equals 1.55 inches per month. The total rainfall for the year equals 55.86 inches, which is 8.49 inches above the normal for this section.

Table 1 contains in detail the records of the rainfall at this Station for the past year, while Table 2 contains the monthly and yearly records since January 1st, 1892. The monthly and yearly normal is also included.

TABLE 1.

Showing Daily and Monthly Precipitation in Inches at the College Farm for the Year Ending October 31st, 1902.

DATE.	November.	December.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.
1	T			0.10	0.08	0.08			0.34			2.47
2				0.50	0.69					0.21	0.04	
3		1.82	0.05		0.08		0.37		0.28	2.11		
4		0.06								0.08	0.02	0.08
5					0.66				0.08			1.00
6						0.09			0.06	0.82		0.88
7						0.85		0.10			0.09	
8			0.14		0.07	1.18						
9			0.10		0.79	0.88					0.68	
10		0.87				0.08			T	0.20	0.25	
11	0.14		0.02			T		0.08		1.21		0.41
12	0.21					0.01		0.17				1.60
13		0.02		T	0.08	T	0.04				0.29	
14	T	0.01						0.72			0.11	
15		1.05							0.14			
16					T				0.07	0.09		
17				1.25	0.85			0.70	0.18			0.05
18		T							T		0.06	
19					T		T	0.20	0.04		T	
20					0.02		0.12		0.01	T	0.88	
21			0.06	0.99				1.74	0.16	0.18	0.16	
22			1.44	1.40					0.08	0.80	0.11	
23		T		0.04								
24	1.72	0.28							0.40			
25	0.06	0.08		0.18			0.04	0.24	1.10		0.81	
26		0.06	0.10	0.89		T	0.15	0.70			0.78	
27		0.97	0.85			0.92	0.79		0.05	0.59	0.45	
28				1.16	0.11						0.89	1.82
29	0.08	2.22	0.13		0.87	0.86		1.48			0.28	
30		0.66	0.21		T	0.59			0.58			
31			0.10		0.04				T			
Total 1902	2.21	7.30	2.70	6.46	3.79	3.09	1.51	6.08	3.42	6.29	6.25	7.76
Normal rainfall	3.74	3.66	3.82	3.64	3.77	3.68	4.02	3.80	4.92	4.93	3.94	3.45

TABLE 2.

Showing Monthly Precipitation in Inches Since January 1st, 1896.

	November.	December.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	Yearly total.
Total, 1896..	....	....	1.68	5.65	5.92	1.41	3.70	4.93	4.37	2.42	4.31	1.62	*36.71
Total, 1897..	2.95	1.59	2.39	2.77	2.47	3.47	6.45	2.50	12.64	3.81	2.10	1.69	44.93
Total, 1898..	4.53	5.09	3.92	3.49	3.09	4.17	7.86	1.18	3.91	6.44	1.46	5.80	50.88
Total, 1899..	7.14	3.16	4.88	5.37	6.63	1.50	2.04	3.54	6.32	3.45	7.30	2.96	54.79
Total, 1900..	4.11	2.06	4.35	5.30	3.40	2.38	5.58	2.64	6.94	2.24	3.30	3.53	45.83
Total, 1901..	4.27	2.32	2.01	0.76	5.19	7.39	5.01	0.81	9.12	8.90	1.86	1.99	49.63
Total, 1902..	2.21	7.30	2.70	6.46	3.79	3.09	1.51	6.08	3.42	6.29	5.25	7.76	55.86
Normal	3.74	3.66	3.82	3.64	3.77	3.68	4.02	3.80	4.92	4.93	3.94	3.45	47.37

* Ten months only.

The Permanent Experiment Plots.

ASPARAGUS AND THE SMALL FRUITS.

The general plan is as follows: In each case, currants and gooseberries excepted, six varieties, or six rows 160 feet long and set in one block, are duplicated, giving twelve rows, of which rows 1 and 7, 2 and 8, etc., are of the same variety. Rows 7 to 12, inclusive, are irrigated as occasion demands, nothing being applied upon rows 1 to 6. Lengthwise, each plot is divided into four equal plots, forty feet long. Those unirrigated are numbers 1 to 4, those irrigated 5 to 8. Plots 1 and 5, 2 and 6, etc., are treated identically, except that plots 5 to 8 are irrigated. The plan for currants and gooseberries is the same, excepting that there are four varieties instead of six, with six plots, twenty-five feet long, instead of eight plots.

Table 3 shows in detail the fertilizers or manures to be applied to the various plots, with the times for application; all of which has been carefully followed the past season. Water was applied to the irrigated plots the last of May and the first of June, as noted in each case.

TABLE 3.

Showing Fertilizers, Amounts and Time Applied to the Different Plots, Asparagus and Small Fruits.

KIND OF FRUIT OR VEGETABLE.	Plots 1 and 5.	Plots 2 and 6.	Plots 3 and 7.	Plots 4 and 8.
Asparagus	20 ts. * yard manure applied in fall.	500 lbs. complete † applied in spring	500 lbs. complete applied in spring; 300 lbs. bone and potash‡ applied in fall.	500 lbs complete applied in spring; 300 lbs. bone and potash applied in fall; 200 lbs nitrate soda applied when cutting ended.
Blackberries ..	20 ts. yard manure applied in fall.	500 lbs. complete applied in spring	500 lbs. complete applied in spring; 300 lbs. bone and potash applied in fall.	500 lbs. complete applied in spring; 300 lbs. bone and potash applied in fall; 200 lbs. nitrate soda applied after blossoming.
Raspberries....	20 ts yard manure applied in fall.	500 lbs. complete applied in spring.	500 lbs complete applied in spring; 300 lbs. bone and potash applied in fall.	500 lbs complete applied in spring; 300 lbs. bone and potash applied in fall; 200 lbs. nitrate soda applied after blossoming.
Strawberries ..	500 lbs. complete applied in spring.	500 lbs comp'ete applied in spring; 150 lbs. nitrate soda applied after blossoming.	500 lbs. B., P. and A. P.§ applied in spring; 150 lbs. nitrate soda applied after blossoming.	500 lbs. B., P. and A. P. applied in spring.
	Plots 1 and 4.	Plots 2 and 5.	Plots 3 and 6.	
Currants	20 ts. yard manure applied in fall.	500 lbs. B., P. and A. P. applied in fall.	500 lbs. B., P. and A. P. applied in fall; 150 lbs. nitrate soda applied after blossoming.	
Gooseberries...	20 ts. yard manure applied in fall.	500 lbs. B., P. and A. P. applied in fall.	500 lbs. B., P. and A. P. applied in fall; 150 lbs. nitrate soda applied after blossoming.	

* The quantities of manure or fertilizer given are in every case the amounts per acre to be applied.

† Complete Fertilizer—a mixture of the best forms of fertilizing constituents, analyzing nitrogen, 4.5 per cent.; phosphoric acid (available), 7.7 per cent., and potash, 13.3 per cent.

‡ An even mixture of ground bone and muriate of potash.

§ An even mixture of ground bone, muriate of potash and acid phosphate.

The general arrangement of plots, fertilizers, etc., allows a study of—

a. The effect of irrigation.

b. The relative effect of fertilizers and manures with and without irrigation—

1. Upon the early yield.
2. Upon the total yield.

c. The effect of the addition of nitrate of soda.

ASPARAGUS.

The plantation was thoroughly worked the 2d of April, crowns uncovered the 12th and ridged preparatory to cutting April 21st. The first cutting of "grass" was taken April 23d, eight days earlier than in 1901. Asparagus was selling in this market upon that date at 18 cents per pound bunch. The last cutting was taken June 20th, making the thirtieth for the season. Asparagus was then selling at 10 cents per bunch.

Manures and fertilizers were applied as follows: December 6th, yard manure to plots 1 and 5, and bone and potash to plots 3, 4, 7 and 8. April 21st, plots 2, 3, 4, 6, 7 and 8 received the complete fertilizer, and plots 4 and 8 the nitrate on July 12th. Water was applied to the irrigated plots 5 to 8 but once this season, giving three-fourths inch of water May 31st.

The records of the year are given in Table 4, together with the annual totals for the four previous crops, and the average per year of the five crops cut from the plantation.

Considering varieties in early yield, Palmetto has not made the showing this season that it has in the past. Of the eight plots, Palmetto leads in early yield on three, Barr's Mammoth on three and Elmira on two plots. The seconds in early yield are Colossal on three plots, Columbian on two, and Barr's Mammoth, Elmira and Palmetto one each.

As in past seasons, Palmetto leads in the total yield upon all plots except plot 5, where it stands fourth in order. It is peculiar that Palmetto, upon plot 5, should fail to respond as it does upon all the other plots, and for three years in succession. The variety second in total yield is apt to vary from year to year; however, looking at

TABLE 4.

Asparagus—Fertilizer Plots.

VARIETY.	UNIRRIGATED.											
	PLOT 1.			PLOT 2.			PLOT 3.			PLOT 4.		
	First three cuttings.	Total cut.	Tops.	First three cuttings.	Total cut.	Tops.	First three cuttings.	Total cut.	Tops.	First three cuttings.	Total cut.	Tops.
	oz.	oz.	lbs.	oz.	oz.	lbs.	oz.	oz.	lbs.	oz.	oz.	lbs.
Barr's Mammoth...	38.5	390.0	17.25	26.0	380.0	12.25	8.0	218.0	9.00	8.0	278.0	11.50
Donald's Elmira.....	30.5	502.0	26.25	21.5	390.5	13.00	18.0	412.5	15.50	15.0	372.0	9.25
Columbian Mammoth White.......	30.0	447.5	22.25	25.5	430.0	14.00	8.0	292.0	9.25	8.0	322.0	11.75
Palmetto............	30.5	651.5	29.50	24.5	519.0	26.00	11.5	465.0	20.25	19.0	457.0	20.25
Conover's Colossal.	34.0	494.5	19.25	18.0	361.5	11.50	16.0	315.5	10.25	12.5	283.0	11.25
Giant Brunswick...	16.5	396.0	18.00	10.5	326.0	11.50	9.5	250.0	6.50	8.0	249.0	9.50
Total	180.0	2881.5	131.50	126.0	2407.0	88.25	70.0	1958.0	70.75	70.5	1961.0	73.50
Totals for 1898..	68.0	288.5	156.00	95.5	234.5	113.50	76.5	176.5	108.00	67.0	153.0	61.00
Totals for 1899..	186.0	697.0	109.50	148.0	620.0	76.50	130.0	537.5	76.00	98.0	420.0	71.50
Totals for 1900..	149.5	1786.5	176.00	229.0	1540.5	118.00	182.0	1389.0	102.00	149.0	1224.0	95.00
Totals for 1901..	63.5	2039.0	242.25	183.0	1645.5	198.75	90.0	1426.5	155.25	71.0	1288.0	157.75
Average per year, five crops	119.4	1528.5	168.05	146.3	1289.5	119.00	109.7	1096.5	102.40	91.1	1009.2	91.75

Asparagus—Fertilizer Plots.

VARIETY.	IRRIGATED.											
	PLOT 5.			PLOT 6			PLOT 7.			PLOT 8.		
	First three cuttings.	Total cut.	Tops.	First three cuttings.	Total cut.	Tops.	First three cuttings	Total cut.	Tops.	First three cuttings.	Total cut.	Tops.
	oz.	oz.	lbs.	oz.	oz.	lbs.	oz	oz.	lbs.	oz.	oz.	lbs.
Barr's Mammoth..	14.0	414.0	30.00	13.5	293.5	10.50	18.0	267.5	10.50	22.0	276.0	13.50
Donald's Elmira....	31.0	457.0	22.50	12.0	431.5	19.50	9.5	284.0	13.50	8.0	358.5	16.50
Columbian Mammoth White.......	27.5	459.0	19.75	23.5	391.5	15.50	6.5	340.5	18.25	15.5	288.0	14.50
Palmetto	16.0	419.5	27.75	32.5	586.0	23.50	33.0	523.0	21.50	18.0	484.0	20.00
Conover's Colossal..	20.0	434.5	20.00	29.5	483.5	17.25	15.0	390.0	16.50	8.5	314.0	10.00
Giant Brunswick...	5.5	256.0	11.00	....	273.0	6.00	4.5	288.5	18.00	5.5	282.5	10.00
Total................	114.0	2420.0	131.00	111.0	2462.0	92.25	86.5	2093.5	88.25	77.5	1943.0	84.50
Totals for 1898..	72.5	224.5	187.50	100.0	288.5	111.50	84.5	196.5	108.50	77.5	164.5	81.00
Totals for 1899..	135.0	668.0	116.50	180.0	658.5	87.00	136.5	589.5	77.00	101.5	490.5	88.50
Totals for 1900..	109.5	1590.5	176.50	206.5	1544.5	186.50	200.0	1447.0	117.00	151.5	1199.0	105.00
Totals for 1901..	56.5	1770.5	283.50	83.0	1806.5	183.50	75.5	1488.5	158.25	58.5	1349.5	191.25
Average per year, five crops	97.5	1894.3	158.80	136.1	1842.0	123.15	116.6	1151.0	106.80	93.2	1029.8	105.65

the results upon the different plots for the four past seasons, Elmira stands second and Columbian Mammoth White third in order.

To further compare varieties, the yields of the different sorts during the five years of cutting from the field are combined and averaged and the results calculated to the basis of one acre. The following contains the figures, as above, with similar figures for the crop of 1902:

	1902.		Average, Five Crops.	
	Early Yield. lbs.	Total Yield. lbs.	Early Yield. lbs.	Total Yield. lbs.
Barr's Mammoth	251.8	4,282.8	255.4	2,396.8
Donald's Elmira	247.6	5,450.1	295.2	3,068.8
Columbian Mammoth White	245.9	5,017.1	284.0	2,684.9
Palmetto	314.8	6,984.9	385.4	4,013 8
Conover's Colossal	259.5	5,132.8	236.0	2,817.4
Giant Brunswick	102.1	3,864.3	92.4	1,660.0
Moore's Cross-Bred	165.1	4,708.4	160.6	2,355 4
Giant Argenteuil	*177.0	*1,626.7	†140.6	†1,049.8

In 1902 Elmira is second, Colossal third and Columbian Mammoth White fourth in yields. Taking the averages of the five crops, Palmetto exceeds by 945 pounds any other sort. Elmira is second, with the Colossal third in total yields.

The wholesale price of asparagus in our market this year averaged, for the early cut, 16 cents per pound, and for the total, 10.46 cents. Allowing 10 per cent. for waste, etc., in bunching, the market value of the early and total yields of Palmetto are $45.33 and $657.56 per acre, exceeding all others by $7.47 and $144.49, respectively, for the early and total yield.

In the combined averages, Palmetto exceeds all others by 63.2 pounds and 945 pounds, worth commercially $9.10 and $88.96 per acre, respectively, for the early cut and the total yield.

Considering the results upon the different plots, the varieties taken together, we have:

(*a*) In early yield, two of the irrigated plots exceed, and two are exceeded by, the unirrigated duplicates. The same is true of the total yields, *i. e.*, two exceeding and two exceeded by the unirrigated duplicates. Taking the four plots in each case together, those unirrigated exceed those irrigated by nearly 15 per cent. in early, and 4 per cent. in total, yields. In the top growth the irrigated plots exceed in three cases and are practically identical in the fourth plot (1 vs. 5).

* Second year's cut.
† Two first years' cutting only.

Considering the annual average of the five crops, plots 1 and 2, unirrigated, and 7 and 8, irrigated, exceed their duplicates in early yield. Taken together, the unirrigated plots exceed those irrigated by a little over 5 per cent.

In total yields and in growth of tops, three of the irrigated plots, *i .e.*, 6, 7 and 8, exceed the unirrigated duplicates. Taken together, however, the unirrigated plots exceed in total yield those irrigated by a little over 1 per cent. In top growth the irrigated plots exceed by 4 per cent. those unirrigated.

(*b*) In early yield, plots 1 and 5 (yard manure) have given the largest cut, with 2 and 6 second. With the totals, plot 1 (manure), unirrigated, and 6 (complete fertilizer). irrigated, lead, with 2 and 5 second. In top growth, 1 and 5 excel, with 2 and 6 second.

Averaging the five crops, the early yield of plots 2 and 6 (complete fertilizer) exceed by 22.5 and 16.7 per cent., respectively, the next plots in yield. In the total yield, plot 1 (manure) exceeds the next in yield, where unirrigated, by 18.5 per cent., and, when irrigated, plots 6 and 5 are practically identical—7.7 pounds per acre in favor of plot 6.

The annual top growth averages much larger upon plots 1 and 5 (manure) than upon the other plots.

(*c*) Nitrate of soda added to plot 4, unirrigated, has given an early yield practically identical with plot 3, and exceeding it somewhat in total yield and top growth, but, where irrigated, plot 8 has given the lowest yields throughout.

Considering where the five crops are averaged the plots receiving nitrate (4 and 8) are the lowest in yield in every case.

Table 5 contains the detailed record for the year of the two new sorts and the two rows set with selected crowns. The yearly totals are also included, as well as the annual yield for the five crops harvested.

With slight variations in early yields, the results upon the different plots are identical with those upon the unirrigated plots already discussed.

It was stated in the last report that "the advantage derived from setting the large selected crowns has entirely disappeared." The same holds true the present year. In all cases the yields obtained upon the permanent plots exceeds that from plots treated identically, but which were originally set with selected crowns.

TABLE 5.

Asparagus—New Varieties and Selected Crowns.

VARIETY.	PLOT 1.			PLOT 2.			PLOT 3.			PLOT 4.		
	First three cuttings.	Total cut.	Tops.	First three cuttings.	Total cut.	Tops.	First three cuttings.	Total cut.	Tops.	First three cuttings.	Total cut.	Tops.
	oz.	oz.	lbs.	oz.	oz.	lbs.	oz.	oz.	lbs.	oz.	oz.	lbs.
Donald's Elmira....	18.5	484.5	21.00	20.0	498.0	19.25	2.5	362.5	11.25	6.0	262.0	8.75
Palmetto...............	24.0	548.0	31.00	20.0	482.5	21.00	14.0	449.0	23.00	8.5	445.5	20.50
Moore's Cross-Bred.	12.5	362.0	13.25	7.0	827.0	10.50	20.0	351.0	12.50	9.0	343.5	10.00
Giant Argenteuil...	2.5	108.0	14.50	13.0	117.0	14.25	20.0	115.0	18.25	16.5	138.0	26.75
Total	52.5	1447.5	79.75	60.0	1814.5	65.00	56.5	1277.5	65.00	40.0	1189.0	66.00
Totals for 1898..	64.5	152.0	95.00	40.0	117.5	61.50	57.5	140.5	86.00	49.0	119.0	68.50
Totals for 1899..	97.0	425.5	59.00	77.5	357.5	49.50	64.0	341.5	47.50	43.5	277.5	45.00
Totals for 1900..	102.0	956.0	95.50	78.5	806.5	94.00	81.5	782.5	93.00	71.5	579.0	72.00
Totals for 1901..	27.5	920.0	120.75	53.5	865.0	121.75	58.0	820.0	120.00	28.0	804.0	180.00
Average per year, five crops...........	68.7	780.3	90.00	61.9	692.0	78.35	63.5	662.4	82.30	46.4	598.7	75.30

BLACKBERRIES.

The plantation was trimmed the 1st of March and the space between rows thoroughly cultivated April 30th. Manure was applied to plots 1 and 5 December 6th, and bone and potash applied at the same time upon plots 3, 4, 7 and 8. May 8th the complete fertilizer was spread upon plots 2, 3, 4, 6, 7 and 8, as per scheme. June 2d nitrate of soda was applied to plots 4 and 8. The irrigated plots received one application of water the past season—*i. e.*, May 31st—giving water equivalent to one inch of rainfall. Table 6 contains the detailed record for the year, together with the annual totals for the four previous crops and the average annual yield for the five crops harvested from the plantation.

A very small crop of fruit was harvested this season, the smallest, in fact, taken since the patch commenced to fruit. Eldorado has been by far the most productive the past season, giving 66.4 per cent. more fruit than any other sort, but yielding only about one-fourth the crop of 1900.

TABLE 6.

Blackberries—Fertilizer Plots.

VARIETY.	Date first picking.	UNIRRIGATED.							
		PLOT 1.		PLOT 2.		PLOT 3.		PLOT 4.	
		Yield first three pickings.	Total yield.	Yield first three pickings.	Total yield.	Yield first three pickings.	Total yield.	Yield first three pickings.	Total yield.
		oz.	oz.	oz.	oz.	oz.	oz.	oz.	oz.
Early Harvest	July 5.	52.5	81.0	28.0	56.0	45.5	94.0	35.0	102.0
Wilson, Jr.	" 14.	47.5	95.0	68.0	192.0	54.0	207.0	65.0	199.0
Erie	" 14.	18.0	66.0	8.0	60.0	2.5	102.0	15.5	156.0
Agawam	" 18.	9.0	30.0	0.5	10.0	2.0	16.0	44.0	91.0
Taylor	" 22.	21.5	51.0	10.5	72.0	12.5	40.0	22.5	144.0
Eldorado	" 11.	8.0	39.0	16.5	196.0	19.0	186.0	37.5	214.0
Total	....	151.5	414.0	126.5	586.0	185.5	644.0	219.5	906.0
Equivalent in quarts	....	6.3	17.3	5.3	24.4	5.6	26.8	9.1	37.8
Totals for 1898, quarts	....	13.8	37.4	16.4	71.5	24.4	87.2	14.8	52.1
Totals for 1899, quarts	....	8.9	39.6	10.7	61.8	16.2	101.1	15.0	90.0
Totals for 1900, quarts	....	35.7	212.8	32.2	209.6	29.4	196.8	32.8	177.8
Totals for 1901, quarts	....	11.3	47.0	10.7	66.5	7.8	48.5	8.2	51.1
Average per year, five crops	....	15.1	80.8	15.1	86.7	16.7	92.1	16.0	81.8

Blackberries—Fertilizer Plots.

VARIETY.	Date first picking.	IRRIGATED.							
		PLOT 5.		PLOT 6.		PLOT 7.		PLOT 8.	
		Yield first three pickings.	Total yield.	Yield first three pickings.	Total yield.	Yield first three pickings.	Total yield.	Yield first three pickings.	Total yield.
		oz.	oz.	oz.	oz.	oz.	oz.	oz.	oz.
Early Harvest	July 5.	39.5	60.0	55.0	86.0	44.0	62.0	62.0	104.0
Wilson, Jr.	" 14.	36.0	73.0	30.5	68.0	2.5	22.0	18.0	57.0
Erie	" 14.	15.5	140.0	6.0	148.0	1.0	67.0	1.5	184.0
Agawam	" 18.	29.5	117.0	10.5	53.0	19.5	73.0	24.0	71.0
Taylor	" 22.	45.0	108.0	36.5	90.0	17.0	63.0	44.5	198.0
Eldorado	" 11.	12.0	142.0	10.5	168.0	17.0	254.0	31.5	282.0
Total	....	167.5	640.0	149.0	613.0	101.0	541.0	181.5	896.0
Equivalent in quarts	....	7.0	26.7	6.2	25.5	4.2	22.5	7.6	34.8
Totals for 1898, quarts	....	27.2	161.1	29.5	103.1	20.8	67.6	26.0	55.6
Totals for 1899, quarts	....	18.3	96.7	17.0	148.9	18.0	131.7	16.0	119.6
Totals for 1900, quarts	....	41.2	207.0	34.7	195.9	33.8	146.4	29.1	142.0
Totals for 1901, quarts	....	15.2	73.4	12.4	70.0	8.2	43.7	9.7	49.5
Average per year, five crops	....	21.8	113.4	20.0	108.7	17.0	82.4	16.5	80.3

Combining the yields of the different varieties upon all plots for the four crops, and calculating the yields on the basis of an acre, we have the following average annual early and total yields from the six varieties grown:

	Early Yield.	Total Yield.
Early Harvest	993.8 quarts.	2,193.3 quarts.
Wilson, Jr.	553.6 "	1,900.8 "
Erie	190.4 "	2,512.0 "
Agawam	392.5 "	2,486.9 "
Taylor	174.2 "	2,007.8 "
Eldorado	411.3 "	2,740.3 "

Eldorado is thus shown to be the most productive sort, averaging 9 per cent. yearly more than the next variety, in order of yield—*i. e.*, the Erie. Wilson, Jr., is the lowest in yield.

Considering the yields of 1902 by plots, we have—

(*a*) Plots 5 and 6, irrigated, exceed their unirrigated duplicates both in early and total yields. In the other two cases the unirrigated plots have the larger yield; combining the four plots in each case the unirrigated plots have the larger early yield, but are exceeded by a little over 3 per cent. in total yields where irrigated.

In the average annual yield from the patch the irrigated plots exceed in all cases in early yield. Combined, the increase equals 19.7 per cent. In total yields, however, only two of the irrigated plots (5 and 6) exceed their unirrigated duplicates. Combining the yields in each case the irrigated plots exceed those not irrigated by 12.7 per cent.

(*b*) The relations between the plots are this year considerably different than in previous years. Where irrigated the results are the same both in early and total yield—*i. e.*, in order, plots 8, 5, 6 and 7. Where not irrigated plot 4 also excels in both early and total yield, with plot 1 second in early and plot 3 second in total yields.

The results of the five crops harvested are the same in the early and total yields where irrigated—*i. e.*, in order, plots 5, 6, 7 and 8. Where unirrigated plot 3 leads in both cases, with plot 4 second in early and plot 2 second in the total yields.

(*c*) Those plots receiving the extra nitrogen (4 and 8) exceed in early and total yield in 1902. Note particularly the large yields upon these plots. The excess over the next plots, in order, equals 25.7 per cent. in early and 35.7 per cent. in the total yields.

In the average crop, however, the nitrate plots (4 and 8), where irrigitated, have given the lowest yields, and where not irrigated standing second in early and third in total yields.

RASPBERRIES.

The raspberry patch has been cared for along with the blackberries, so that the same dates apply in either case. Plots 5 to 8 received two applications of water (May 30th and July 13th), giving an inch cf water each time. Table 7 contains the year's records, together with previous records, as in other cases.

A comparison of varieties by yields is unnecessary, since they do not compare, Cuthbert being by far the better sort. Marlboro is earlier, wherein its value lies. Turner is an abundant yielder, but the character of the fruit is such that it is undesirable, either for home or market.

By plots we have—

(*a*) Irrigation has increased the early yield in all cases and, in all but plot 6, total yield, where the unirrigated plot has slightly the larger yield. The combined figures give an increase of 14.3 per cent. and 8.2 per cent., respectively, for early and total.

In the average crop harvested the early yield is the larger where irrigitated, excelling by 15.3 per cent. The greatest increase occurs upon plot 5. In total yields two plots are exceeded by the unirrigated duplicates, but combined irrigation gives an increase of 5.4 per cent.

(*b*) With one exception, the results of the different plots are the same throughout—*i.e.*, in order of numbering, plots 1 and 5, 2 and 7, 3 and 6, 4 and 8. The exception occurs in plot 7, which exceeds in yield plot 6.

Averaging the five crops harvested the different plots stand as numbered in early yield. In total yields plots 3 and 5 are first, with plots 2 and 7 second in order.

(*c*) Plots 4 and 8, to which nitrate of soda was added, have given the lowest yields throughout early and total yields, both in 1902 and in the average annual crop.

TABLE 7.

Raspberries—Fertilizer Plots.

VARIETY.	Date first picking.	UNIRRIGATED.							
		PLOT 1.		PLOT 2.		PLOT 3.		PLOT 4.	
		Yield first three pickings.	Total yield.	Yield first three pickings.	Total yield.	Yield first three pickings.	Total yield.	Yield first three pickings.	Total yield.
		oz.	oz.	oz.	oz.	oz.	oz.	oz.	oz.
Cuthbert	June 30.	91.5	411.0	43.5	303.0	44.0	286.0	36.0	229.0
Marlboro	" 27.	33.5	157.0	33.0	206.0	49.0	291.0	31.5	178.0
Turner	" 27.	40.5	284.0	43.5	351.0	43.0	349.0	56.0	468.0
Gregg	" 27.	21.0	62.0	22.5	47.0	16.5	40.0	14.5	67.0
Souhegan	" 24.	136.0	258.0	113.5	246.0	83.5	179.0	43.0	83.0
Total		322.5	1,172.0	256.0	1,153.0	236.0	1,145.0	181.0	1,025.0
Equivalent in quarts		14.7	53.3	11.6	52.4	10.7	52.0	8.2	46.6
Totals for 1898,* quarts		7.0	23.7	2.4	11.7	2.4	11.4	2.6	10.3
Totals for 1899,* quarts		12.4	38.4	6.1	37.2	6.0	33.3	3.0	24.2
Totals for 1900,* quarts		2.9	33.6	7.7	46.8	5.8	49.5	3.2	36.8
Totals for 1901, quarts		6.0	31.7	12.1	44.8	12.2	48.7	13.2	42.2
Average per year, five crops		8.6	36.1	8.0	38.5	7.4	39.0	6.0	32.0

Raspberries—Fertilizer Plots.

VARIETY.	Date first picking.	IRRIGATED.							
		PLOT 5.		PLOT 6.		PLOT 7.		PLOT 8.	
		Yield first three pickings.	Total yield.	Yield first three pickings.	Total yield.	Yield first three pickings.	Total yield.	Yield first three pickings.	Total yield.
		oz.	oz.	oz.	oz.	oz.	oz.	oz.	oz.
Cuthbert	June 30.	58.0	370.0	47.5	267.0	36.0	253.0	44.5	228.0
Marlboro	" 27.	62.0	373.0	29.5	194.0	46.5	293.0	26.5	230.0
Turner	" 27.	56.0	363.0	64.5	427.0	37.5	366.0	37.5	400.0
Gregg	" 27.	32.5	71.0	7.0	14.0	17.5	44.0	10.5	22.0
Souhegan	" 24.	142.5	265.0	141.0	239.0	142.0	254.0	98.5	191.0
Total		351.0	1,442.0	289.5	1,141.0	279.5	1,210.0	217.5	1,071.0
Equivalent in quarts		16.0	65.5	13.2	51.9	12.7	55.0	9.9	48.7
Totals for 1898,* quarts		8.7	41.5	2.9	14.0	2.8	13.6	2.2	11.2
Totals for 1899,* quarts		12.0	40.6	7.3	39.3	6.0	41.5	6.0	32.2
Totals for 1900,* quarts		4.5	37.5	5.5	40.5	4.8	47.4	3.9	30.5
Totals for 1901, quarts		9.2	39.0	11.4	39.0	13.5	45.9	9.8	33.7
Average per year, five crops		10.1	44.8	8.1	36.9	8.0	40.7	6.4	31.1

* Three varieties only.

CURRANTS AND GOOSEBERRIES.

Plots 1 and 5 received manure and the other four plots the mixture of bone, potash and acid phosphate, the 6th of December. May 6th, nitrate of soda was given plots 3 and 6. Bushes were trimmed the last of March, and the ground thoroughly cultivated April 30th. Plots 4, 5 and 6 received water twice—May 26th and June 13th—applying an inch each time. Table 8 contains full records as in previous cases.

Currants.—Of the four sorts grown, Fay's Prolific finds readier sale, because of its larger size. It is not, however, nearly as productive as the other red sorts. The average annual yield per acre of the four sorts for the past four years are—

Fay's Prolific	**3,106.3 quarts.**	**Victoria**	**6,720.8 quarts.**
Red Dutch	**7,150.9 "**	**White Grape**	**3,423.1 "**

In keeping the record of yields of the currants, the weights of the product of each bush is made separately. In connection with the low annual yield of Fay's Prolific, it is important and instructive to note some of these individual bushes. There are six plots of seven each, and in each plot wide variations in yield exist between different bushes, and such differences are in evidence year after year.

In the following table is given the record of a few of these bushes, the figures being the total yield to date—six crops—during the fruiting life of the bush. The good and poor are from the same plot and are set opposite each other:

Good.		Poor.	
Plot 1, Bush 3	191.5	Plot 1, Bush 7	148.0
" 2, " 3	276.0	" 2, " 7	200.5
" 2, " 6	290.0		
" 3, " 2	271.0	" 3, " 4	19.5
" 3, " 5	246.5	" 3, " 7	22.0
" 4, " 3	302.0	" 4, " 5	156.0
" 4, " 4	334.0	" 4, " 7	40.0
" 5, " 2	253.5	" 5, " 5	35.0
		" 5, " 7	16.5
" 6, " 7	330.0	" 6, " 3	72.5
		" 6, " 5	51.0
Average	277.17	Average	76.10

TABLE 8.

Currants—Fertilizer Plots.

VARIETY.	UNIRRIGATED.			IRRIGATED.		
	Plot 1.	Plot 2.	Plot 3.	Plot 4.	Plot 5.	Plot 6.
	oz.	oz.	oz.	oz.	oz.	oz.
Fay's Prolific	412.0	598.0	259.0	523.0	223.0	406.0
Red Dutch	965.0	659.0	995.0	889.0	928.0	1,028.0
Victoria	843.0	649.0	806.0	945.0	726.0	977.0
White Grape	578.0	473.0	652.0	557.0	398.0	593.0
Total	2,798.0	2,379.0	2,711.0	2,864.0	2,275.0	3,004.0
Equivalent in quarts	139.9	119.0	135.6	143.2	113.8	150.2
Totals for 1898, quarts	13.3	3.4	8.8	17.8	11.3	9.4
Totals for 1899, quarts	41.2	37.5	49.8	51.8	51.6	50.9
Totals for 1900, quarts	62.7	61.0	58.9	82.0	68.1	60.6
Totals for 1901, quarts	109.0	96.0	108.0	129.8	105.0	107.3
Average per year, five crops	78.2	63.6	71.2	84.9	70.0	75.7

Gooseberries—Fertilizer Plots.

VARIETY.	UNIRRIGATED.			IRRIGATED.		
	Plot 1.	Plot 2.	Plot 3.	Plot 4.	Plot 5.	Plot 6.
	oz.	oz.	oz.	oz.	oz.	oz.
Downing	1,768.0	1,037.0	1,016.0	1,758.0	977.0	946.0
Columbus	395.0	148.0	191.0	366.0	107.0	324.0
Houghton	1,134.0	888.0	734.0	1,058.0	616.0	602.0
Triumph	259.0	254.0	147.0	580.0	80.0	315.0
Total	3,556.0	2,327.0	2,088.0	3,762.0	1,780.0	2.187.0
Equivalent in quarts	151.8	99.0	83.9	160.1	75.7	93.1
Totals for 1898, quarts	29.7	22.9	26.4	37.5	21.8	24.8
Totals for 1899, quarts	86.3	47.5	74.6	70.6	59.5	66.2
Totals for 1900, quarts	158.7	98.2	125.0	161.9	123.4	134.5
Totals for 1901, quarts	47.2	34.9	31.3	44.2	40.6	45.0
Average per year, five crops	94.6	60.5	69.2	94.9	64.2	72.7

Calculating these figures to the basis of one acre, and averaging, we would have from plants yielding at this rate 4,695.3 quarts in the one case, and only 1,289.1 in the other. These figures include, in averaging, the first two years of fruiting, and are much smaller than if these years were not included, though the relations would be practically the same. Taking the four best plants as the basis for calculating, we would have yields of 5,319.2 quarts per acre.

As a general law in plant growing, "like begets like," hence the great importance, as the facts presented show, of taking cuttings for propagation only from bushes of known producing power when we wish to increase and maintain productive currant plantation. We have a lot of plants under way taken from these several bushes.

Considering the results from the different plots in 1902, we have:

(*a*) An increase on two of the three plots irrigated. Combined, the increase over the unirrigated plots equals over 3 per cent.

(*b*) Plot 1, manure, unirrigated, and plot 6, chemical mixture, with nitrate, irrigated, have the largest yields.

(*c*) Where not irrigated the plot receiving the extra nitrate is second, and where irrigated, first in yields.

In the same manner, considering the average of the five crops harvested, we have:

(*a*) An increase, in all cases where irrigated, equaling together 10.76 per cent.

(*b*) Plots 1 and 4, manure, are first, and 3 and 6, chemical mixture, with nitrate, second in yield.

(*c*) The nitrated plots stand second in yield.

Gooseberries.—Combining the yields in the five crops upon all plots of the different varieties, we have the following comparative yields per acre of the different sorts:

Downing	**7,955.3 quarts.**	**Columbus**	**2,739.4 quarts.**
Houghton	**8,819.9 "**	**Triumph**	**2,499.9 "**

The plot work of 1902 shows that—

(*a*) The irrigated plots have the larger yield in two of the three cases; combined, however, the unirrigated plots have the larger yield by a little over 3 per cent.

(*b*) Plots 1 and 4 (manure) have by far the largest product.

(*c*) Where unirrigated the nitrate plot is lowest, and where irrigated, second in order of yield.

Similarly, for the average annual crop, we have—

(*a*) An increase upon the irrigated plots, in all cases, equaling together together 3.3 per cent.

(*b*) Manure upon plots 1 and 4 has given much the larger product, exceeding the next plots in order over 33.5 per cent.

(*c*) Where extra nitrate of soda is added, plots 3 and 6, an increase is given over those plots treated identically, excepting the application of nitrate of soda, equaling 13.8 per cent.

STRAWBERRIES.

The beds fruiting this year were set originally in August, 1899. In 1900 fruit was obtained only from the first plants set. Good matted rows were formed for fruiting in 1901. After harvesting the crop in 1901 the spaces between the rows were cut out, leaving a strip about fifteen inches wide along the original row. This strip was thoroughly cleaned out and spaces between rows worked up, and the bed left for fruiting another season.

April 28th and May 19th, fertilizers, as outlined, were applied. Three applications (May 26th, June 4th and 13th) of water were made upon plots 5 to 8, inclusive, giving one inch, one and one-half inches and one inch, respectively.

The results of the year's work are given in Table 9, together with the totals and averages of the previous crops grown upon the fertilizer plots.

The yields obtained are small, particularly on the lower end of the patch or plots 4, 7 and 8, where the plants did not grow well after cleaning out in 1901.

The following figures show the comparative yields of the six varieties grown, and includes the five crops, large and small together. Yields are per acre, in quarts:

Sharpless	1,935.0	Glen Mary	*4,474.9
Bubach	4,491.6	Gandy	3,100.8
Downing	2,788.5	Marshall	2,567.2

* Three crops only.

TABLE 9.

Strawberries—Fertilizer Plots.

VARIETY.	Date first picking.	UNIRRIGATED.							
		PLOT 1.		PLOT 2.		PLOT 3.		PLOT 4.	
		Yield first three pickings.	Total yield.	Yield first three pickings.	Total yield.	Yield first three pickings.	Total yield.	Yield first three pickings.	Total yield.
		oz.	oz.	oz.	oz.	oz.	oz.	oz.	oz.
Sharpless	June 4.	49.5	280.0	47.5	222.0	88.0	176.0	5.5	81.0
Bubach	May 29.	71.5	286.0	81.0	278.0	18.0	279.0	6.0	188.0
Downing	" 29.	82.0	205.0	26.5	166.0	20.0	161.0	12.5	127.0
Glen Mary	" 29.	89.0	301.0	25.5	249.0	9.0	188.0	8.0	169.0
Gandy	June 6.	37.0	244.0	12.5	190.0	16.0	204.0	9.0	111.0
Marshall	May 29.	36.5	239.0	28.5	172.0	17.0	191.0	9.0	90.0
Total		265.5	1,505.0	217.5	1,272.0	118.0	1,149.0	50.0	764.0
Equivalent in quarts		14.0	79.2	11.4	66.9	5.9	60.5	2.6	40.2
Totals for 1897, quarts		16.4	86.2	14.5	91.2	12.1	81.0	12.8	78.6
Totals for 1898, quarts		26.0	64.7	24.9	58.5	20.2	42.4	17.0	36.3
Totals for 1900, quarts		7.5	25.5	8.9	26.9	6.6	17.1	5.0	15.0
Totals for 1901, quarts		27.1	128.6	28.9	188.9	19.9	125.5	18.1	188.8
Average per year, five crops		18.2	76.8	17.7	75.5	12.9	65.8	11.0	60.7

Strawberries—Fertilizer Plots.

VARIETY.	Date first picking.	IRRIGATED.							
		PLOT 5.		PLOT 6.		PLOT 7.		PLOT 8.	
		Yield first three pickings.	Total yield.	Yield first three pickings.	Total yield.	Yield first three pickings.	Total yield.	Yield first three pickings.	Total yield.
		oz.	oz.	oz.	oz.	oz.	oz.	oz.	oz.
Sharpless	June 4.	81.5	158.0	88.5	143.0	22.5	90.0	9.5	48.0
Bubach	May 29.	68.5	451.0	79.5	379.0	37.0	252.0	38.0	282.0
Downing	" 29.	38.0	228.0	16.5	124.0	18.0	108.0	12.5	87.0
Glen Mary	" 29.	86.0	361.0	18.5	273.0	15.0	229.0	11.5	186.0
Gandy	June 6.	21.0	274.0	7.5	188.0	9.5	85.0	5.5	94.0
Marshall	May 29.	16.5	149.0	7.0	64.0	1.0	48.0	8.5	86.0
Total		211.5	1,611.0	162.5	1,116.0	98.0	812.0	85.5	728.0
Equivalent in quarts		11.1	84.8	8.6	58.7	5.2	42.7	4.5	38.3
Totals for 1897, quarts		16.8	76.8	12.8	56.1	16.1	82.8	17.8	87.9
Totals for 1898, quarts		27.6	61.5	25.0	62.6	25.4	49.2	20.7	40.8
Totals for 1900, quarts		5.6	19.1	7.6	20.8	7.7	20.4	6.4	17.4
Totals for 1901, quarts		19.1	105.6	28.8	120.6	19.1	94.8	21.6	126.1
Average per year, five crops		16.0	69.6	16.6	63.7	14.7	56.0	14.2	62.0

Taking the results by plots, we have—

(*a*) An increase is obtained where irrigated only on plot 8, early yield, and on plot 5, total yield.

(*b*) Plots 1 and 5 have given the largest yields in both the early and total product. The complete fertilizer has given better results than has the mixture of bone, potash and acid phosphate.

(*c*) The complete fertilizer alone has given larger yields than where nitrate of soda was added on plots 2 and 6. Nitrate added to the other mixture (plots 3 and 7) has given an increase in all cases.

In the average annual crop we have—

(*a*) An increase under irrigation on two plots, early yield, and one plot in the total yields.

(*b*) Excepting plot 6, early yield, plots 1 and 5 have given the largest yield throughout. The complete fertilizer has given better yields than has the mixture used on plots 3, 4 7 and 8.

(*c*) Nitrate of soda added to the complete fertilizer gives an increase on plot 6, early yield, only. Added to the mixture of bone, potash and acid phosphate an increase is given in all cases, excepting plot 7, total yield, where plot 8, the mixture alone, has the larger yield.

THE TREE FRUITS.

The general plan follows: The plots extend crosswise the rows, so that each plot includes two trees of each row; each row being a different variety. A cross line of trees is set between plots, to separate the plots and prevent interfeeding, and at the same time test some of the newer varieties of the different fruit trees. Thus arranged, trees 1, 2, 4, 5, 7, 8, 10 and 11 of each row are included in the plots, while 3, 6, 9 are varieties. Table 10 shows in detail the plan for fertilizers, amounts and times of application.

TABLE 10.

Showing Fertilizer, Amounts and Time of Application for the Various Fruit Trees.

KIND OF FRUIT.	Plot 1.	Plot 2.	Plot 3.	Plot 4.
Apples	Nothing.	500 lbs.‖ B. P. & A. P.† applied in spring.	500 lbs. B. P. & A. P. applied in spring.	
Peaches	Nothing.	500 lbs. B. P. & A. P. applied in spring.	500 lbs. B. P. & A. P. applied in spring; 150 lbs. nitrate soda applied early and turned under	500 lbs. P. & A. P.‡ applied in spring; 150 lbs. nitrate soda applied early and turned under.
Standard Pears	Nothing.	500 lbs. B P. & A. P. applied in spring.	500 lbs. B. P. & A. P. applied in spring; 150 lbs. nitrate soda applied early and turned under.	
	Plots 1 and 4.*	Plots 2 and 5.	Plots 3 and 6.	
Dwarf Pears	Nothing.	500 lbs. B. P. & A. P. applied in spring.	500 lbs. B. P. & A. P. applied in spring; 150 lbs. nitrate soda applied early and turned under.	
	Plots 1 and 3.*	Plots 2 and 4.		
Plums / Cherries	500 lbs. B. P & A P. applied in spring.	500 lbs. B. P & A. P. applied in spring; 150 lbs. nitrate soda applied early and turned under.		

‖ The quantities of fertilizers given are in all cases the amount per acre to be applied.

† An even mixture of ground bone, muriate of potash and acid phosphate.

‡ A mixture of muriate of potash and acid phosphate in the proportion of 1 lb. of the former to 2 lbs. of the latter.

* Plots 1, 2 and 3, Dwarf Pears, and 1 and 2, Plums and Cherries, are irrigated as occasion demands.

The orchards were pruned as needed during March. On May 9th nitrate of soda was applied to all plots, as per plan, and the ground plowed. The general application of fertilizers was made May 21st. The plots to be irrigated as needed (plots 1 and 2, plums and cherries, and 1, 2 and 3, dwarf pears) received two inches of water June 5th.

PLUMS AND CHERRIES.

Lombard and Newman, of the plums, were well loaded with fruit, while the other two varieties bore a fair quantity. Brown rot was quite troublesome this season. The trees were sprayed early, before buds started, with strong Bordeaux; later spraying, with the mixture sufficiently weak to not injure the foliage, seemed to have little effect in controlling the rot, so that, finally, picking off the affected fruit was resorted to. In all cases of trees in the plot work, this rotten fruit was weighed and the amount taken from each tree given in the tables separately from the good fruit obtained. Newman is hardly affected by the rot, but the excessive rainfall caused considerable of the fruit to crack in the later pickings. This was separately weighed and is given in the table as culls.

The ice storm of February 22d did considerable damage to the plum orchard, particularly the Newman variety. Hardly a tree of this variety escaped injury and some were severly broken, though none had to be removed. Of the other varieties, only one tree was severely broken—*i. e.*, tree 1, plot 1, Lombard.

Of the cherries, Early Richmond gave a good crop, with a fair one on Louis Phillippe, and only a little on the Large Montmorency.

The records of the year, together with the totals per tree for the three previous crops, and the total yield per plot to date, are given in Table 11.

Definite conclusions are not warranted, because of the shortness of the fruiting life of the trees, and because of the variations existing between trees of the same variety, particularly with the Newman plum.

The first tree of this variety in plot 1, with the three main branches removed as the result of the ice storm, gave almost ninety pounds of fruit, while tree 1, plot 4, broken but slightly, gave only thirty-five and one-half pounds.

Tree 2, plot 1, Lombard plum, gave 144 pounds, while tree 2, plot 4, gave only 18½ pounds. Tree 1, plot 1, Early Richmond cherry, gave 8½ pounds, while tree 2, plot 2, gave 38½ pounds. Variations of this nature are noticeable throughout, and occur upon the same trees year after year.

TABLE 11.

Plums and Cherries—Fertilizer Plots.

VARIETY.	Date marketable.	IRRIGATED.				UNIRRIGATED.			
		PLOT 1.		PLOT 2.		PLOT 3.		PLOT 4.	
		TOTAL YIELD.		TOTAL YIELD.		TOTAL YIELD.		TOTAL YIELD.	
		Tree 1.	Tree 2.	Tree 1.	Tree 2.	Tree 1.	Tree 2.	Tree 1.	Tree 2.
Plums.		lbs. oz.	lbs. oz.	lbs. oz.	lbs. oz.	lbs. oz.	lbs. oz	lbs. oz.	lbs. oz.
Lombard—Good....	Aug. 26.	85— 8	115— 5	60— 4	88—13	56— 8	54— 7	59—13	10— 5
Lombard—Rotten..	....	12—12	29— 1	41— 5	49— 8	25— 2	80— 8	85—14	8— 2
Newman—Good. ...	Aug. 3.	74— 1	110— 6	42—12	66—11	148—15	67— 4	31— 6	28— 5
Newman—Culls.....	....	15—10	20— 4	3— 1	46—15	53— 7	5—12	4— 1	3— 3
Shropeshire Damson—Good.........	Sept. 2.	0— 6	0— 1	21— 8	19—13	23— 4	12— 1	19—15	11— 7
Shropeshire Damson—Rotten	....	0— 8	....	7— 4	5— 6	8— 2	8—11	5— 5	4—12
Grand Duke—Good	Sept 12.	3— 5	10— 0	3— 5	5— 9	6— 2	8— 1	2—10	3— 7
Grand Duke-Rotten......................	....	2—13	4—13	8— 2	3— 8	2—15	1— 8	2—11	1—12
Totals, per plot..	....	484—13	....	438— 7	....	517— 6	....	288— 0	....
Totals, three crops, 1899, 1900, 1901.	....	48— 2	95—10	57—12	162— 1	198— 5	51—10	24— 7	18—14
Totals per plot, to date, four crops.	....	578— 9	....	658— 4	....	762— 5	....	276— 5	....
Cherries.									
Large Montmorency	June 24.	0— 5	1— 4	0— 2	0— 7	0— 7	0— 8	1—11	0—14
Louis Philippe.......	" 18.	1— 8	8— 6	5—11	8— 2	2—11	0— 8	8—11	2— 3
Early Richmond...	" 16.	8— 8	21— 8	19— 5	88— 7	21— 6	21—12	8—13	16— 8
Totals, per plot..	....	35—13	....	67— 2	....	46—15	....	33—12	....
Totals, three crops, 1899, 1900, 1901.. ..	....	2— 4	17—15	6—15	17—14	12— 6	18—13	8— 6	9— 4
Totals, per plot, to date, four crops.	....	56— 0	....	91—'5	....	78— 2	....	51— 6	....

With these facts in mind, and considering only the four years' totals, the irrigated plots have given considerably larger yields than those unirrigated. Irrigation seemed to delay ripening, noticeable chiefly upon the Lombard plum, where the irrigated plots were picked six days later, and then were not as mature as the fruits picked from the trees unirrigated. Nitrate of soda added early and turned under when irrigated, plot 2, has given the larger yield, but where unirrigated, plot 4, it is the lowest in yield.

Varieties.—The records of the varieties are given in table 12, and include the yields to date, as well as that of the season of 1902. Burbank, of the plums, is the most productive sort, with Abundance second in order. Satsuma Blood is the third in order. It has the reputation of being quite irregular in fruiting.

Of the cherries, Montmorency Ordinaire and English Morello are quite productive of the acid fruits characteristic of this class of cherries. Of the two Duke's, May Duke is the earlier and more productive. Reine Hortense stands by itself; the fruit is large, bright red, juicy and nearly sweet. Tree 1 has made a good growth and is quite productive. The second tree is barely half the size of tree 1.

TABLE 12.

Plums and Cherries—Varieties.

VARIETY.	Date marketable.	CROP 1902. TOTAL YIELD.		YIELD TO DATE. TREES SET SPRING 1896.	
		Tree 1.	Tree 2.	Tree 1.	Tree 2.
Plums.		lbs. oz.	lbs. oz.	lbs. oz.	lbs. oz.
Imperial Gage	Aug. 28.	2—12	....	2—12	....
Victoria	" 16.	0—12	0— 9	0—12	0— 9
Bavay's Green Gage	Sept. 6.	22— 5	18— 1	25—15	17— 8
Burbank	Aug. 5.	109—14	55— 6	114—12	67— 0
Abundance	" 6.	51— 1	45— 1	62— 1	45— 8
French Damson	Sept. 2.	2— 4	0—12	2— 4	1— 9
Satsuma Blood	Aug. 22.	47—12	41—10	48— 1	42— 7
Cherries.					
Ostheim	June 18.	2—15	4— 2	7—12	9— 0
Royal Duke	" 24.	8— 9	6— 0	14—14	8— 1
English Morello	" 28.	26— 5	22— 9	47—18	39—15
Montmorency Ordinaire	" 24.	20—10	28—10	41— 8	58— 6
Reine Hortense	" 16.	16— 4	0— 6	19— 1	1— 8
May Duke	" 11.	20— 1	6— 5	21—15	0—15.

DWARF PEARS.

The two dwarf varieties, Lawrence and Bartlett, gave this year a fair quantity of fruit. Of the dwarfs, by cutting a few of the Lawrence and Bartlett trees, gave a little fruit, with the Keiffer yielding quite heavily. The records of the year, together with the previous yields per tree and the yields to date per plot, are given in table 13.

Definite conclusions should not be drawn, yet the results are quite interesting. Of the crop of 1902, plot 1, no fertilizer, but irrigated, has the largest yield, with plot 4, no fertilizer, and unirrigated, lowest. Plots 3 and 6, receiving the nitrate of soda early, and turned under, have the largest yields (plot 1 excepted in total yield), with the average size per fruit, three-fourths of an ounce, where irrigated, and and one-fourth of an ounce, where not irrigated, larger than on any other plot.

In the total yields to date the irrigated plots have by far the larger yield, but the results by plots are exactly reversed. Plot 1, no fertilizer, is the lowest where irrigated, and its duplicate highest where unirrigated. Plot 3, fertilizer, with nitrate, is highest where irrigated and the duplicate lowest where unirrigated. Plots 3 and 6 have, however, the largest average per fruit.

Varieties.—The yields of the varieties in 1902 and to date are given in Table 14. Theft reduced the yield in one case—*i. e.,* Clairgean, very materially, we know, but as to losses from this cause in other cases we do not know. Of the dwarfs, White Doyenne, and of the dwarfs by cutting, Le Conte, have given the largest yields to date.

TABLE 13.

Dwarf Pears—Fertilizer Plots.

VARIETY.	IRRIGATED.																	
	PLOT 1.						PLOT 2.						PLOT 3.					
	TREE 1.			TREE 2.			TREE 1.			TREE 2.			TREE 1.			TREE 2.		
	Number of fruits.	Weight.	Average per fruit.	Number of fruits.	Weight.	Average per fruit.	Number of fruits.	Weight.	Average per fruit.	Number of fruits.	Weight.	Average per fruit.	Number of fruits.	Weight.	Average per fruit.	Number of fruits.	Weight.	Average per fruit.
Dwarfs.		lbs. oz.	oz.		lbs. oz.	oz.		lbs. oz	oz.		lbs. oz.	oz.		lbs. oz.	oz.		lbs. oz.	oz.
Lawrence	45	11—15	4.24	10	2—5	3.70	14	3—12	4.29	15	3—11	3.93	5	1—5	4.20	9	2—15	5.22
Bartlett	.....	.....	.....	1	0—9	9.00	.....	.....	.....	8	3—10	7.25	32	16—3	8.09	32	13—14	6.94
Dwarfs by Cutting																		
Lawrence	3	0—10	3.33	9	2—11	4.78	.....	.....	.....	.....	.....	.....	.....	.....	.....	5	1—7	4.60
Bartlett	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Keiffer	164	38—12	3.78	14	4—15	5.64	53	18—9	5.60	30	10—5	5.50	25	9—11	6.20	42	14—13	5.64
Totals, per plot	246	61—13	4.02	.....	.....	.....	120	39—15	5.33	.....	.....	.....	150	60—4	6.43	.....	.....	.....
Totals, two crops, 1900 and 1901	92	27—6	4.76	8	2—2	4.25	70	20—9	4.70	137	40—2	4.69	82	25—11	5.01	69	20—13	4.82
Totals, per plot, to date, three crops	346	91—5	4.22	.....	.....	.....	327	100—10	4.92	.....	.....	.....	301	106—12	5.67	.....	.....	.....

TABLE 13—Continued.

Dwarf Pears—Fertilizer Plots.

VARIETY.	UNIRRIGATED.																	
	PLOT 4.						PLOT 5.						PLOT 6.					
	TREE 1.			TREE 2.			TREE 1.			TREE 2.			TREE 1.			TREE 2.		
	Number of fruits.	Weight.	Average per fruit.	Number of fruits.	Weight.	Average per fruit.	Number of fruits.	Weight.	Average per fruit.	Number of fruits.	Weight.	Average per fruit.	Number of fruits.	Weight.	Average per fruit.	Number of fruits.	Weight.	Average per fruit.
Dwarfs.		lbs. oz.	oz.		lbs. oz.	oz		lbs. oz.	oz.		lbs. oz.	oz.		lbs. oz	oz.		lbs. oz.	oz.
Lawrence	16	5— 0	5.00	......	......	......	12	2— 5	3.08	1	0— 6	6.00	44	10—12	3.90	14	0— 0	5.71
Bartlett	......	......	......	3	1— 5	7.00	3	0—11	3.67	1	0— 8	8.00	24	10— 1	6.71	7	1—12	4.00
Dwarfs by Cutting.																		
Lawrence	......	......	......	......	......	......	......	......	......	......	......	......	2	0— 9	4.50	2	0— 9	4.50
Bartlett	4	1— 3	4.75	......	......	......	......	......	......	......	......	......	5	1— 4	4.00	......	......	......
Keiffer	57	18—12	5.26	20	5— 0	4.80	22	6—14	5.00	69	22— 6	5.19	32	15—18	6.91	16	5— 6	5.50
Totals, per plot	100	32— 4	5.16	......	......	......	108	33— 2	4.91	......	......	......	146	49— 4	5.40	......	......	......
Totals, three crops, 1900 and 1901	122	39—10	5.20	66	18— 1	4.38	32	9—11	4.84	130	36— 5	4.47	38	11— 2	4.68	......	......	......
Totals, per plot, to date, three crops	288	89—15	5.00	......	......	......	270	79— 2	4.69	......	......	......	184	60— 6	5.25	......	......	......

TABLE 14.

Dwarf Pears—Varieties.

VARIETY.	Date marketable.	CROP 1902. Tree 1. Number of fruits.	Tree 1. Weight.	Tree 1. Average per fruit.	Tree 2. Number of fruits.	Tree 2. Weight.	Tree 2. Average per fruit.	YIELD TO DATE—TREES SET SPRING 1896. Tree 1. Number of fruits.	Tree 1. Weight.	Tree 1. Average per fruit.	Tree 2. Number of fruits	Tree 2. Weight.	Tree 2. Average per fruit.
Dwarfs.			lbs oz	oz.		lbs. oz.	oz.		lbs. oz	oz.		lbs. oz	oz.
Margaret	Aug. 11.	13	2—2	2.62	41	8—6	3.27	13	2—2	2.62	72	14—11	3.26
Clapp's Favorite	" 11.	2	1—0	8.00	3	0—15	5.00	5	1—15	6.20	5	1—10	5.20
Howell	....	1	0—4	4.00	4	0—14	3.50	31	7—0	3.61	18	5—1	4.50
Angouleme	Sept. 16.	1	0—9	9.00	....	....	....	10	5—13	9.30	4	2—13	11.25
White Doyenné	" 16.	22	7—13	5.68	13	5—9	6.85	32	10—9	5.28	37	10—15	4.73
Seckel	....	....	....	....	4	1—2	4.50	8	1—3	2.38	6	1—9	4.17
Dwarfs by Culling.													
Le Conte	Sept. 16.	22	8—5	6.05	15	5—1	5.40	58	21—5	5.88	37	12—15	5.59
Clairgeau	" 10.	4	3—0	12.00	....	....	....	5	3—4	10.40	4	1—15	7.75
Belle Lucretine	" 6.	....	....	....	24	7—11	5.13	....	....	....	33	10—12	5.21
Margaret	Aug. 26.	2	0—11	5.50	....	....	....	2	0—11	5.50	....	....	....
Howell	....	....	....	....	....	....	....	7	1—3	2.71	....	....	....

STANDARD PEARS.

The Keiffer trees were this year filled with fruit, with many of the Lawrence and Bartlett trees carrying a fair amount. Table 15 contains all data as in previous cases.

Plot 2, receiving fertilizer, has given the largest yield, with plot 3, the duplicate of 2, with the addition of nitrate of soda, applied early and turned under, lowest in yield. The blank plot, No. 1, stands second in yield.

Varieties.—Table 16 contains the records to date, and are chiefly a matter for record.

TABLE 15.

Standard Pears—Fertilizer Plots.

VARIETY.	Plot 1.						Plot 2.						Plot 3.					
	Tree 1.			Tree 2.			Tree 1.			Tree 2.			Tree 1.			Tree 2.		
	Number of fruits.	Weight.	Average per fruit.	Number of fruits.	Weight.	Average per fruit.	Number of fruits.	Weight.	Average per fruit.	Number of fruits.	Weight.	Average per fruit.	Number of fruits.	Weight.	Average per fruit.	Number of fruits.	Weight.	Average per fruit.
		lbs. oz.	oz.		lbs. oz.	oz.		lbs. oz.	oz.		lbs. oz.	oz.		lbs. oz.	oz.		lbs. oz	oz.
Lawrence	5	1—10	5.20	6	2— 3	5.83	10	2— 6	3.80	10	2—14	4.60	7	1—11	3.86	19	6— 0	5.05
Bartlett	......	......	......	17	6— 0	5.65	49	23— 4	7.59	8	3— 8	7.00	12	5— 4	7.00	26	11— 4	6.92
Keiffer	282	78—10	4.46	219	61—13	4.52	121	51— 1	6.75	381	128— 3	5.38	176	62— 3	5.65	111	42— 4	6.09
Sheldon	6	2—15	7.83	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
Seckel	1	0— 4	4.00	9	2— 0	3.56	......	......	......	......	......	......	......	......	......	......	......	......
Totals, per plot	445	155— 7	4.56	......	......	......	579	211— 4	5.84	......	......	......	351	128—10	5.86	......	......	......
Totals, two crops, 1900 and 1901	142	49— 7	5.57	251	86—10	5.52	125	40—10	5.20	212	71—12	5.42	187	66— 7	5.68	177	62— 3	5.62
Totals, per plot, to date, three crops	838	291— 8	5.57	......	......	......	916	323—10	5.65	......	......	......	715	257— 4	5.76	......	......	......

TABLE 16.

Standard Pears—Varieties.

VARIETY.	Date marketable.	CROP OF 1902.						YIELD TO DATE. TREES SET SPRING 1896.					
		TREE 1.			TREE 2.			TREE 1.			TREE 2.		
		Number of fruits.	Weight.	Average per fruit	Number of fruits.	Weight.	Average per fruit.	Number of fruits.	Weight.	Average per fruit.	Number of fruits.	Weight.	Average per fruit.
			lbs. oz.	oz.		lbs. oz.	oz.		lbs. oz.	oz.		lbs. oz	oz.
Koonce	......	......	......	......	......	......	......	......	......	......	10	2— 6	3.80
P. Barry	Sept. 16.	......	......	......	9	4—13	8.56	21	6—14	5.24	29	12— 0	6.62
Dorset	" 16.	1	0— 6	6.00	39	14— 1	5.77	5	1— 9	5.00	49	16—12	5.47
Angel	Aug. 27.	44	18— 4	6.64	3	1— 0	5.33	58	23— 3	6.40	14	3— 9	4.07
Winter Nelis	Sept. 16.	......	......	......	13	2—11	3.31	26	5—15	3.65	20	4— 8	3.60
Lady Clapp	Aug. 20.	1	0— 5	5.00	......	......	......	11	3— 5	4.82	......	......	......

PEACHES.

The ice storm of February 22d did considerable damage to the peach orchard. Seven trees were so much injured that they were removed and new ones set. Many of the others had large branches split and bent over. In several cases these were drawn back into place and bolted, and in others removed entirely. Of the trees in plots, tree 2, plot 1, in both Elberta and Crawford's Late, and tree 1, plot 2, Reeve's Favorite, were removed. The varieties Wonderful and Butler's Late also had to be taken out. The following newer sorts were set in places thus made vacant: two trees each of Alexander, Chair's Choice and Foster, and one tree of Wonderful. This last sort was originally included, and, as it seemed a desirable late variety, one tree was reset for further observation.

Table 17 contains the data of the year's work, together with the average annual yield of the four crops taken from the plantations.

TABLE 17.

Peaches—Fertilizer Plots.

VARIETY.	PLOT 1.													
	TREE 1.							TREE 2.						
	TOTAL YIELD.							TOTAL YIELD.						
	Number of fruits.	Weight.	Per cent. No. 1 fruits.	Average per fruit.	Per cent. No. 2 fruits.	Average per fruit.	Number thinnings.	Number of fruits.	Weight.	Per cent. No. 1 fruits.	Average per fruit.	Per cent. No. 2 fruits.	Average per fruit.	Number thinnings.
		lbs. oz		oz.		oz.			lbs oz.		oz.		oz.	
Susquehanna	399	75— 2	82.8	3.4	15.9	2.2	746	285	49— 0	78.8	3.4	19.2	1.8	580
Stevens' Rareripe	1,282	78— 8	....	....	87.2	1.0	1,956	609	58— 0	....	....	90.4	1.6	1,105
Elberta	749	97— 7	51.2	2.5	46.1	1.9	1,671	....	....	....	....	....	....	....
Crawford's Late	314	29— 5	2.1	2.5	90.0	1.6	698	....	....	....	....	....	....	....
Reeve's Favorite	380	48— 8	30.4	2.6	65.3	1.9	405	....	....	....	....	....	....	....
Old Mixon	965	104— 0	11.3	2.4	85.8	1.7	1,292	784	74—12	19.3	2.6	76.6	1.5	1,075
Totals, per plot	7,110	784— 9	32.8	2.8	62.5	1.6	12,292	....	....	....	....	....	....	....
Average totals, four crops	5,101	612—11	43.6	2.9	50.7	1.6	4,645	....	....	....	....	....	....	....
Totals, per plot, excluding Stevens' Rareripe	5,269	653— 6	39.4	2.8	57.2	1.7	9,281	....	....	....	....	....	....	....
Average totals, four crops	3,606	485— 8	49.6	2.9	45.6	1.8	3,407	....	....	....	....	....	....	....

TABLE 17—Continued.

Peaches—Fertilizer Plots.

VARIETY.	PLOT 2. Tree 1. Total yield. Number of fruits.	Weight.	Per cent. No. 1 fruits.	Average per fruit.	Per cent. No. 2 fruits.	Average per fruit.	Number thinnings.	Tree 2. Total yield. Number of fruits.	Weight.	Per cent. No. 1 fruits.	Average per fruit.	Per cent. No. 2 fruits.	Average per fruit.	Number thinnings.
		lbs. oz.		oz.		oz.			lbs. oz.		oz.		oz.	
Susquehanna	254	38— 3	64.7	3.2	30.9	1.8	581	192	17—4	2.5	2.8	78.9	1.6	200
Stevens' Rareripe	386	29—14	....	....	86.2	1.5	625	548	57—9	....	....	91.1	1.7	1,153
Elberts	154	21— 1	57.6	2.7	87.4	1.9	866	174	25—2	55.5	2.9	40.0	2.0	568
Crawford's Late	361	41— 0	13.9	2.6	88.9	1.8	677	344	45—7	39.5	2.5	59.0	1.9	498
Reeve's Favorite	....	....	....	....	....	....	....	700	113—6	68.2	2.9	29.8	2.1	641
Old Mixon	664	88—12	24.2	2.6	72.2	2.1	745	1,012	131—9	41.2	2.5	55.6	1.9	1,065
Totals, per plot	5,484	722— 9	42.2	2.8	58.5	1.9	7,558	....	....	....	....	....	....	....
Average totals, four crops	4,408	551— 8	45.8	2.5	49.6	1.8	8,219	....	....	....	....	....	....	....
Totals, per plot, excluding Stevens' Rareripe	4,555	685— 2	48.0	2.8	48.6	2.0	5,780	....	....	....	....	....	....	....
Average totals, four crops	3,380	456— 2	49.4	2.6	45.9	1.9	2,476	....	....	....	....	....	....	....

TABLE 17—Continued.

Peaches—Fertilizer Plots.

VARIETY.	PLOT 3. TREE 1. TOTAL YIELD. Number of fruits.	Weight.	Per cent. No. 1 fruits.	Average per fruit.	Per cent. No. 2 fruits.	Average per fruit.	Number thinnings.	PLOT 3. TREE 2. TOTAL YIELD. Number of fruits.	Weight.	Per cent. No. 1 fruits.	Average per fruit.	Per cent. No. 2 fruits.	Average per fruit.	Number thinnings.
		lbs. oz.		oz.		oz.			lbs. oz.		oz.		oz.	
Susquehanna	43	11— 9	93.5	4.6	5.4	2.5	81	193	27— 8	49.0	3.0	46.2	2.0	290
Stevens' Rareripe	524	80— 6	....	....	63.2	1.6	1,797	470	47— 6	8.6	2.0	52.4	1.5	601
Elberta	390	66— 2	71.0	3.2	28.5	2.1	516	356	65— 0	76.7	3.4	15.0	2.1	337
Crawford's Late	392	67— 2	49.6	3.0	48.6	1.9	546	448	60—13	41.5	2.6	57.7	1.9	616
Reeve's Favorite	379	69—11	79.3	3.3	17.8	2.1	861	650	120— 4	75.0	3.2	24.1	2.4	585
Old Mixon	995	117— 9	19.6	2.5	77.7	1.8	1,160	1,804	163—11	28.4	2.7	67.0	1.9	1,415
Totals, per plot	6,444	886—12	44.3	3.1	47.2	1.9	8,455	....	....	....	....	....	....	....
Average totals, four crops	4,700	654—13	45.6	3.0	47.3	2.0	3,977	....	....	....	....	....	....	....
Totals, per plot, excluding Stevens' Rareripe	5,150	759— 0	51.3	3.1	45.8	1.9	5,857	....	....	....	....	....	....	....
Average totals, four crops	3,448	499— 7	52.6	3.0	42.0	2.0	2,708	....	....	....	....	....	....	....

TABLE 17—Continued.

Peaches—Fertilizer Plots.

VARIETY.	PLOT 4.													
	TREE 1.							TREE 2.						
	TOTAL YIELD.							TOTAL YIELD.						
	Number of fruits.	Weight.	Per cent No. 2 fruit.	Average per fruit.	Per cent. No. 2 fruits.	Average per fruit.	Number thinnings.	Number of fruits.	Weight.	Per cent. No. 1 fruits.	Average per fruit.	Per cent. No. 2 fruits.	Average per fruit.	Number thinnings.
		lbs. oz.		oz.		oz.			lbs. oz.		oz.		oz.	
Susquehanna	96	24— 8	93.6	4.3	4.9	2.7	245	76	16— 7	84.0	4.0	11.8	2.2	260
Stevens' Rareripe	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Elberta	581	108— 1	80.5	3.2	16.7	2.1	936	289	58—14	68.9	3.8	26.8	2.1	728
Crawford's Late	748	110—13	53.8	2.8	33.9	2.1	1,385	183	37— 0	85.7	3.5	11.8	2.3	343
Reeve's Favorite	697	123— 7	76.2	3.2	22.8	2.1	870	380	92— 8	96.5	4.6	3.4	2.5	333
Old Mixon	1,097	153—14	30.2	2.7	66.2	2.2	1,881	812	105— 9	37.0	2.5	59.1	2.0	347
Totals, per plot	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Average totals, four crops	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Totals, per plot, excluding Stevens' Rareripe	4,909	821— 1	62.9	3.3	33.8	2.1	6,788	....	....	....	....	....	....	....
Average totals, four crops	3,000	505— 4	65.8	3.3	30.4	2.1	2,684	....	....	....	....	....	....	....

In those cases where one tree of a variety in a plot is out, the yield of the tree remaining is doubled in getting the totals for that plot, so that in all cases the totals given are for a full plot of 12 trees.

The method of taking the records has been the same in this as in previous years—*i. e.*, sorting into firsts, seconds and culls, but instead of giving the records as made, only the total yield is given, with the percentages of firsts and seconds, with the average size of the same in each case.

The first totals given are to be used in comparing the first three plots only. The second, excluding Stevens' Rareripe, are to be used in comparing all four plots.

In the last report* attention was called to the marked variations occurring between different trees of the same variety, both as regards quantity of fruit produced and the proportion of the same grading firsts. Similar variations upon the same trees are in evidence this year.

Considering the first three plots—*i. e.*, plot 1, check, plot 2, even mixture bone, potash and acid phosphate, and plot 3, same as 2, with nitrate of soda added early and turned under, the results of the crop of 1902 and the annual four years' average are the same.

Plot 1 has set the most fruit; more has been removed in thinning and still more left on the tree to ripen than on either the other plots. The weight of fruit, however, is exceeded by that from plot 3, but it exceeds that from plot 2. The percentage of fruits, grading firsts, is larger upon plot 3 and lowest on plot 1. The average weight per fruit is likewise larger upon plot 3 than upon either the other two plots.

Plot 4 received a mixture of potash and acid phosphate, one part potash to two parts of acid phosphate, with nitrate of soda applied early and turned under. Taking the totals from the same plots—Stevens' Rareripe excluded—the result of the 1902 crop and the four-year average practically agree. The result of the first three plots likewise agree with the totals from these plots when Stevens' Rareripe is included.

Plot 1 has set the largest number of fruits; more has been removed in thinning, still leaving more upon the tree to ripen than upon any other plot. The yield of fruit, however, is largest upon plot 4 and second largest upon plot 3, third upon plot 1 and lowest upon plot 2. The percentage of first grading fruits and the average weight of the same is largest upon plot 4 and second largest upon plot 3.

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*Annual Report 1901, page 249.

TABLE 18.

Peaches—Varieties.

VARIETY.	Date marketable.	Tree 1. Number of fruits.	Tree 1. Weight.	Tree 1. Per cent. No 1 fruits.	Tree 1. Average per fruit.	Tree 1. Per cent. No. 2 fruits.	Tree 1. Average per fruit.	Tree 1. Number thinnings.	Tree 2. Number of fruits.	Tree 2. Weight.	Tree 2. Per cent. No. 1 fruits.	Tree 2. Average per fruit.	Tree 2. Per cent. No. 2 fruits.	Tree 2. Average per fruit.	Tree 2. Number thinnings.	Average annual yield, four crops. Total weight.	Average annual yield, four crops. Average per fruit.
			lbs. oz		oz.		oz.			lbs. oz.		oz.		oz.		lbs. oz.	oz.
Sneed	July 10	283	30—5	56.1	2.0	36.9	1.4	239	25	1—7	....	....	78.3	1.1	10	*29—9	1.7
Triumph	Aug. 1	183	8—3	....	....	54.2	1.3	1,751	306	24—1	10.4	1.8	71.2	1.4	3,020	51—14	1.4
Champion	" 23	755	189—9	79.4	3.8	16.8	2.2	1,071	654	121—2	77.7	3.3	16.9	2.2	778	190—2	2.8
Surpasse	" 26	158	84—0	89.0	3.7	10.7	2.8	324	293	33—6	52.6	2.6	43.2	1.8	415	*51—14	2.6
Crosby	Sept. 10	991	96—11	6.2	2.6	88.8	1.6	2,585	375	51—6	49.8	2.9	44.0	2.0	1,164	132—10	2.0
Ward's Late White	" 22	959	95—1	6.0	2.5	70.7	1.6	1,998	662	59—9	....	....	70.8	1.5	1,724	143—4	1.8

*Three crops only.

These two plots (3 and 4) received a dressing of nitrate of soda at the rate of 150 pounds per acre, applied early and turned under. The influence of this extra nitrogen was noticeable throughout the season in the dark green, vigorous foliage. Contrasted with the very dark green of trees on these plots, trees on plot 2 were yellowish and those of plot 1 light green in color.

Varieties.—Table 18 contains the records of the six varieties fruiting in 1902, together with the average annual yield since the trees were set.

Sneed is the earliest fruiting sort, maturing July 10th. One tree has failed to grow properly. The other is fairly productive. It is *not a vigorous grower and quite crooked in manner of growth.*

Triumph is situated between plots 1 and 2 of the fertilizer plots and shows the lack of proper treatment. It is the second earliest sort.

The table shows the season and productiveness of the other varieties.

APPLES.

This is the first year of fruiting, and Table 19 contains the yields to date of all trees in the fertilizer plots and of the varieties. Plot 1 received no fertilizers and has not been cropped, while plots 2 and 3 have received a mixture of bone, potash and acid phosphate annually and the ground between the trees has been used for the vegetable garden each year since setting. The records of the year are presented only as a matter for record.

TABLE 19.

Apples—Fertilizer Plots and Varieties.

VARIETY.	PLOT 1.				PLOT 2.				PLOT 3.			
	TREE 1.		TREE 2.		TREE 1.		TREE 2.		TREE 1.		TREE 2.	
	Number of fruits.	Weight.	Number of fruits.	Weight.	Number of fruits.	Weight.	Number of fruits.	Weight.	Number of fruits.	Weight.	Number of fruits	Weight.
		lbs. oz.		lbs. oz.		lbs. oz.		lbs. oz.		lbs. oz		lbs. oz.
Smith's Cider	202	40— 1	10	1— 5	91	17— 9	136	22— 8	14	1— 9	43	6— 3
King	2	1— 0	8	3— 8	1	0— 7	......	......	3	1— 7	......	......
Jonathan	1	0— 6	32	0—14	15	3— 7	19	5— 5	......	......	7	1— 8
Oldenburg	......	......	10	2— 5	28	5—12	84	14—13	9	1—13	11	2— 8
Varieties.												
Ben Davis	36	7— 5	67	18— 5	......	......	......	......	......	......	......	......
Yellow Transparent	45	6—11	9	1—13	......	......	......	......	......	......	......	......
Williams' Favorite	7	1— 7	......	......	......	......	......	......	......	......	......	......
Barry	56	13— 5	1	0— 4	......	......	......	......	......	......	......	......

PEAS, BEANS AND SWEET CORN WITH FERTILIZERS.

In a previous report* the results were given of a fertilizer test with early peas and beans, followed with sweet corn and with crimson clover, sown in the latter as early as possible in August.

Since that report was made the same line of work has been continued upon the same ground, increasing, however, the applications of manures and fertilizers by 50 per cent. and doubling the rows of peas and beans, planting two rows ten inches apart instead of single rows, as in the first test. Each of the five plots are approximately one-twenty-fifth acre in area and are treated as follows:

*Annual Report 1898, page 167.

Plot 1. Check.
" 2. Manure, 15 tons per acre.
" 3. Mixture: { Muriate of potash, 1 lb. / Acid phosphate, 2 lbs. } 788 lbs per acre.
" 4. { Potash and acid phosphate, 788 lbs per acre. / Nitrate of soda, 225 lbs. per acre }
" 5. { Potash and acid phosphate, 788 lbs. per acre. / Nitrate of soda, 75 lbs. per acre. / Dried blood, 225 lbs. per acre. }

This plan of plots has been followed for seven seasons, so that plot 1, while growing two crops each year, has had nothing applied to it.

One-half of each plot is planted to peas and the other half to beans. Each year the peas—edible condition—have been harvested, and the vines removed before the corn was planted. With the beans, however, the corn is planted between the rows, since the crop—snap beans—does not mature early enough to remove the vines before necessary to plant the corn. Approximate dates of planting the different seeds each year are—

Peas, April 15th to 20th.
Beans, April 28th to May 4th.
Sweet corn, July 1st to 7th.
Crimson clover, August 10th to 15th.

Good crops of peas and beans have been obtained each year, excepting 1901, when the dry spring cut the pea and bean crop nearly or quite two-thirds.

With one exception, also due to climatic conditions of the season, fair crops of sweet corn have matured the last of September and first of October. In 1899, frost on October 2d cut the crop before the later sorts matured. Other seasons' frosts have held off until the 22d, or later, of October, and the corn has had plenty of time to mature. Crimson clover is hardly satisfactory to use in this connection. While we have been able to secure fair stands, it cannot be sown early enough and give the sweet corn the cultivation that seems desirable; and in spring the land is plowed too early to secure any benefit in spring growth. Some quick-growing fall crop, as rye, would probably be better adapted for furnishing humus to the soil, even though it did not add nitrogen.

Tables 20, 21 and 22 contain the average annual yields of the different sorts of peas, beans and sweet corn, respectively, with the totals for the plots.

TABLE 20.

Peas—Fertilizer Plots.

VARIETY.	PLOT 1.				PLOT 2.				PLOT 3.				PLOT 4.				PLOT 5.			
	Amount first picking.	Total yield.	Weight, 100 plants.	Total weight, vines.	Amount first picking.	Total yield.	Weight, 100 plants.	Total weight, vines.	Amount first picking.	Total yield.	Weight, 100 plants.	Total weight, vines.	Amount first picking.	Total yield.	Weight, 100 plants.	Total weight, vines.	Amount first picking.	Total yield.	Weight, 100 plants.	Total weight, vines.
	oz.	oz.	oz.	oz.	oz.	oz.	oz.	oz.	oz.	oz.	oz.	oz.	oz.	oz.	oz.	oz.	oz.	oz.	oz.	oz.
Nott's Excelsior	60.5	91.5	9.8	78.0	106.5	169.3	20.4	166 0	80.8	117.0	11.9	96.0	95.0	147.0	17.4	187.0	108.8	147.5	20.1	185.0
Little Gem	37.5	70.0	12.8	76.0	63.0	127.3	25.9	170.0	56.0	90.8	18.4	95.0	71.0	117.3	22.1	180.0	77.0	124.3	26.1	140.0
Premium Gem	53.0	79.3	12.0	69.0	89.8	146.8	20.8	176.0	88.5	115.8	19.8	116.0	82.5	125.0	17.1	125.0	86.3	132.5	20.8	144.0
American Wonder	35.8	48.0	12.0	39.0	57.8	86.5	30.8	92.0	62.5	82.0	24.5	61.0	56.5	74.3	24.0	61.0	66.0	87.5	24.0	74.0
Chelsea	42.0	71.0	10.8	60.0	67.8	127.3	18.5	120.0	62.8	99.8	16.5	79.0	75.0	127.0	16.9	108.0	82.0	125.5	16.8	109.0
O'Rourke	41.0	57.0	6.3	41.0	78.5	129.8	13.1	98.0	58.5	92.8	8.8	60.0	72.0	110.0	9.9	78.0	71.8	118.0	9.8	74.0
Tom Thumb	30.0	64.3	10.1	63.0	49.5	106.5	13.4	128.0	49.3	90.5	11.1	79.0	61.8	118.0	10.8	128.0	67.0	128.0	18.4	114.0
Best Extra Early	49.3	71.3	7.4	54.0	70.0	132.5	9.8	119.0	65.5	98.0	7.6	78.0	80.8	122.8	12.4	87.0	91.8	183.5	14.9	106.0
Alaska	45.5	66.8	7.1	57.0	69.5	124.0	9.0	119.0	51.8	84.3	5.1	70.0	69.8	116.5	9.0	94.0	76.8	126.8	9.8	88.0
Selected Extra Early	39.8	73.0	5.9	59.0	66.3	123.5	8.1	108.0	45.5	74.0	6.8	68.0	67.3	109.8	9.3	85.0	64.5	118.0	11.1	95.0
Totals, per plot	488.9	692.2	98.2	591.0	712.2	1273.5	169.8	1296.0	615.7	999.5	130.0	792.0	730.7	1162.2	148.4	1028.0	787.0	1281.1	166.8	1078.0

TABLE 21.

Beans—Fertilizer Plots.

VARIETY.	PLOT 1.				PLOT 2.				PLOT 3.				PLOT 4.				PLOT 5.			
	Amount first picking.	Total yield.	Weight, 40 plants.	Total weight, vines.	Amount first picking.	Total yield.	Weight, 40 plants.	Total weight, vines.	Amount first picking.	Total yield.	Weight, 40 plants.	Total weight, vines.	Amount first picking.	Total yield.	Weight, 40 plants.	Total weight, vines.	Amount first picking.	Total yield.	Weight, 40 plants.	Total weight, vines.
	oz.	oz.	oz.	oz.	oz.	oz.	oz.	oz.	oz.	oz.	oz.	oz.	oz.	oz.	oz.	oz.	oz.	oz.	oz.	oz.
Currie's Rust Proof Wax	44.8	85.3	9.1	185.0	96.8	171.5	15.5	256.0	85.0	74.8	10.8	127.0	61.5	118.0	13.9	208.0	60.5	115.5	12.5	215.0
Refugee Wax	20.8	86.8	11.6	173.0	41.5	182.5	18.8	299.0	18.5	81.0	12.1	147.0	35.0	189.8	13.8	244.0	26.8	105.0	16.5	283.0
Golden Wax	43.8	83.3	14.5	111.0	94.0	172.8	17.5	207.0	84.0	77.8	15.9	118.0	65.5	125.5	22.4	168.0	62.5	119.5	14.8	155.0
Davis' White Wax	40.5	112.0	14.8	118.0	80.5	228.5	37.6	253.0	84.8	112.0	16.5	154.0	68.8	178.3	19.0	231.0	66.0	174.5	19.8	212.0
Flageolet Wax	44.3	111.0	16.0	179.0	61.8	189.0	25.5	248.0	37.8	106.0	17.9	202.0	51.0	168.5	19.8	247.8	52.8	162.3	24.6	268.0
Early Warwick	69.5	108.3	9.9	165.0	106.8	177.5	16.5	280.0	63.5	106.3	12.1	175.0	81.8	152.5	15.6	251.0	90.0	159.0	14.8	265.0
Emperor William	18.7	52.0	25.8	77.0	18.8	117.0	45.0	164.0	22.0	85.0	80.5	183.0	22.0	99.8	38.5	158.0	82.7	104.8	44.0	151.0
Stringless Green Pod	33.8	67.5	13.4	168.0	68.0	153.8	28.9	327.0	84.5	68.5	16.3	187.0	50.3	111.5	17.1	261.0	51.8	106.5	19.6	276.0
Early Valentine	29.8	84.3	10.1	149.0	72.5	200.8	19.9	297.0	31.8	102.5	14.5	180.0	87.5	129.8	17.2	283.0	48.0	147.0	15.9	265.0
Ex-Early Refugee	22.8	62.0	8.5	157.0	45.0	182.8	16.0	326.0	27.5	71.8	11.6	172.0	36.5	118.5	12.6	265.0	26.8	107.0	13.4	269.0
Totals, per plot	368.8	847.0	133.4	1422.0	684.7	1726.2	285.7	2657.0	339.4	885.2	158.2	1590.0	509.9	1386.7	190.0	2261.0	517.4	1300.6	195.4	2809.0

TABLE 22.

Sweet Corn—Fertilizer Plots.

VARIETY.	PLOT 1.			PLOT 2.			PLOT 3.			PLOT 4.			PLOT 5.		
	Number of ears.	Weight of ears.	Weight of fodder.	Number of ears.	Weight of ears.	Weight of fodder.	Number of ears.	Weight of ears.	Weight of fodder.	Number of ears.	Weight of ears.	Weight of fodder.	Number of ears.	Weight of ears.	Weight of fodder.
		lbs. oz.	lbs.		lbs. oz.	lbs.		lbs. oz.	lbs.		lbs. oz.	lbs.		lbs. oz.	lbs.
Perry Hybrid	52	18— 8	24.8	70	30— 8	41.8	73	26—15	36.7	74	25— 2	43.5	62	23— 9	34.2
Stablers' Early	54	17—15	38.4	100	39— 6	64.2	66	22— 4	46.8	77	29—15	56.8	65	24—12	49.3
Roslyn Hybrid	73	29— 6	47.1	107	49— 4	78.8	80	36— 4	62.8	83	33— 8	67.7	65	27—12	54.2
Stowell's Evergreen	41	18— 0	46.7	61	28—10	80.2	52	25— 8	69.5	46	23— 5	58.6	45	18— 5	52.7
Country Gentleman	34	9—15	53.1	82	31— 0	93.3	64	28— 5	74.4	60	19—11	65.5	56	16—14	48.5
Totals, per plot	254	93—12	210.1	420	178—12	358.3	335	134— 4	290.2	340	130— 9	292.1	293	111— 4	238.9

Peas.—The early product from the different plots is shown by the figures in the first column under each plot. In the second and fourth columns in each case is given the total yield of edible peas and the weight of vines removed after harvesting the peas. The weight of 100 plants at the end of each variety in each plot is also given.

The most productive of the varieties are Nott's Excelsior and Premium Gem, of the wrinkled sorts, and Best Extra Early and Alaska of the earlier smooth sorts.

The results by plots, all varieties combined, are, briefly—

Plot 5 leads in early yield by 7.7 per cent. Plot 4 is second.
" 2 leads in total yield by 3.4 per cent. Plot 5 is second.
" 2 has largest weight for first 100 plants Plot 5 is second.
" 2 has largest total weight of vines. Plot 5 is second.

Yard manure, plot 2, thus leads in yield in all cases but the early product. Plot 5 is likewise second throughout. The difference in yield in favor of plot 2 over plot 5 is very small, amounting for an acre to approximately four and one-fourth bushels. Compared with the check plot, the increase is very large, amounting to 84 per cent., and over minerals only, plot 3, the increase equals 35.6 per cent. Minerals alone have given an increase over check plot of 35.7 per cent.

Beans.—The tables are similar to that for peas. Of the wax beans, Davis' White and the Flageolet are the most productive, with the other wax sorts very nearly alike in yield. Early Warwick and Early Valentine are the most productive of the green pod sorts. By plots the results, combining all varieties, are—

Plot 2 leads in early yield by over 32 per cent. Plot 5 is second.
" 2 leads in total yield by over 29 per cent. Plot 4 is second.
" 2 has largest weight for first 40 plants. Plot 5 is second.
" 2 has largest total weight of vines. Plot 5 is second.

Yard manure thus leads throughout, with plot 5 second in all except the total yield, when plot 4 stands second in order. The increase of plot 2 over 4 in total yield is approximately forty-eight and one-half bushels per acre. Compared with the check plot, the increase in favor of the manure plot is over 100 per cent., and the increase over minerals equals 95 per cent. Minerals only, plot 3, give but little larger yields than does the check plot—*i. e.*, 885 to 847, respectively. The lack of nitrogen upon this plot (3) is very plainly evident in the color of the foliage and size of the plants. While the plants of

plot 1 show a light greenish color, and are about half the size of those of plot 2, the plants of plot 3, about the same size, are decidedly yellowish in color.

Sweet Corn.—In the table is given the number and weight of the edible ears produced and the weight of the fodder. The selection of varieties has been made to secure a succession. The order of maturing is as given in the table, excepting that the Evergreen comes after the Country Gentleman.

On the lower side of the field the sweet corn has not developed satisfactorily. The table shows that plot 4 gives but little larger yields than obtained upon plot 3, while plot 5 gives considerably less than that from plot 3. Plot 2 leads in yield throughout and with plot 4 second. The percentage increase of 2 over 4 equals 28. Compared with the check plot the increase in yield of ears and fodder of plot 2 equals 91 and 70 per cent., respectively. The increase from minerals only over the check plot is 43 per cent. in yield of ears and 38 per cent. in yield of fodder. In all main particulars the results of this test confirm the results obtained in the first test, previously reported. The relations, however, between the yields of the check plot (No. 1) and the plot receiving minerals only (No. 3) and the yields of the other plots has constantly widened. The rate of decrease, though, has been greater in the check plot than where the minerals only were used in the yields of peas and sweet corn, but with the beans the difference between these two plots have become less and less.

Doubling the number of rows and increasing the amount of manure and fertilizers 50 per cent. has not resulted in a proportionate increase in the yields from the different plots. The very small yield, however, of the one season is included in the average yields given.

PEAS AND TOMATOES—DOUBLE CROPPING.

In the report of 1898 the results were given of a test of double cropping with peas and tomatoes, testing, at the same time, the effect of fertilizers and fertilizers with lime upon our soil. It was stated then that the two crops could be grown very successfully together and that the plot receiving lime with the fertilizer gave a small increase with peas and a considerable increase with tomatoes over the yields obtained with fertilizers alone.

In this test the rows of peas were planted much farther apart than seemed necessary and, in continuing the work, the peas were planted at the usual distances. The plots were enlarged slightly, so that each contained approximately one-eighty-sixth acre in area, and are treated as follows:

Plot 1. Check.
" 2. Complete fertilizer, 500 lbs. per acre.
" 3. Complete fertilizer, 500 lbs. per acre, 1½ tons per acre lime, applied in 1896, and again in 1902.

Peas were planted early in the season upon each plot, giving seven double rows, three feet apart. Only the early dwarf sorts are desirable for this purpose. In due time tomato plants were set between every other row of peas, giving twenty plants per plot.

Table 23 contains the average annual yields of both peas and tomatoes.

TABLE 23.

Peas and Tomatoes—Double Cropping with Fertilizer and Lime.

PLOT.	PEAS.				TOMATOES.				
	Amount first picking.	Total yield.	Weight, 200 plants.	Total weight of vines.	Amount first six pickings.	Total yield marketable fruits.	Average size per fruit.	Culls.	Rotten fruit.
	lbs. oz.	lbs. oz.	oz.	lbs. oz.	lbs. oz.	lbs. oz.	oz.	%	%
Plot 1. Blank	28—8	34—15	22.4	33—9	21—5	72—13	4.67	9.8	4.0
" 2. Fertilizers	29—5	46—10	28.2	47—7	45—8	124—6	4.82	8.4	5.8
" 3. Fertilizers and lime	24—14	44—8	26.6	45—0	41—7	108—9	4.88	9.8	4.8

The two crops are very successfully grown upon the same ground. With peas the yields obtained are fully as large as in other cases. With tomatoes, also, very good yields per plant are obtained. On the acre basis the yields are small, because of the greater space given each plant, the plants being set four and one-half by six feet, and because, in combining another experiment with this, one-half the plants in each plot are quite productive, while the other half is much less so.

The yield of plot 2, fertilizers alone, exceeds that of 3, where lime was added. In studying the annual yield, however, the yield of plot 3 is seen to decrease slightly each year, showing that the effect of the lime was rapidly passing away. In the yields of 1902, however, plot 3 has given yields in both peas and tomatoes, exceeding by considerable that from plot 2.

No attempt has been made to grow rye or crimson clover after harvesting the tomato crop, thus adding humus to the soil—a procedure that seems quite desirable.

REPORT OF THE ASSISTANT IN DAIRY HUSBANDRY.

DAIRY HUSBANDRY.

The principal lines of work pursued in this department during the past year were as follows:

The study of forage crops, including crop rotations, cost and yield of forage, and new varieties.

The retail milk business, including the cost of production, sale and wastes in handling and delivery.

Daily records have been kept of the dairy herd and the milk of each animal analyzed semi-monthly, the results of which are reported.

Considerable time has been given to the analysis of milk by the "Babcock Method" during the past six years, the number of analyses amounting to 10,400. In addition to the regular work in this direction, samples are frequently sent to the Station by farmers, dairymen and breeders' associations. The number received from these sources during the past year amounted to 185 samples of milk and ten samples of cream.

The use of the disk harrow in removing weeds and reseeding alfalfa was made the subject of an experiment, the results of which are reported.

Experiments were continued in growing cow peas and corn for silage.

A study was made of the comparative value of forage crops and silage for dairy cows, covering a period of six years.

Nitrate of soda as a top dressing for rye, wheat and barnyard millet was made a subject of study and its effect upon the yield and value of the crop noted.

The effect of lime upon land where forage crops have been grown continuously for a number of years was studied; the crops used being cow peas, soy beans and forage corn.

A study was made of a number of cover crops and their adaptability for different soils and conditions.

Experiences in the use of the "Schmidt Treatment" as a cure for milk fever are noted, four cases being reported.

The dairy business in relation to soil exhaustion has been continued for six years and the results showing the gains and losses to the farm are reported.

Since the last report was issued Bulletin No. 158, "Soiling Crop Experiments," and No. 161, "Alfalfa, Cow Peas and Crimson Clover as Substitutes for Purchased Feeds—Home-Grown Protein versus Purchased Protein," have been published and the following general conclusions were drawn from them:

1. A rotation may be arranged, including crops that thrive well, early and late, which will provide a continuous supply of forage for a dairy herd from May 1st to November 1st.

2. The value of a plant for forage is determined by its yield, composition, palatability, season of the year in which it may be grown, time required for it to mature and its effect upon the flavor of milk.

3. The soiling system has the advantage over pasture, in that it provides a uniform supply of succulent food, which is very important in the retail milk business.

4. Three crops can be grown upon the same acre in one season, as, for example, rye, oats and peas and corn, yielding a total of twenty tons or more; with the perennial plant, alfalfa, five crops have been secured, with a yield of 26.6 tons of green forage per acre.

5. The herd consumed an average of sixty pounds of green forage per cow per day, with six to eight pounds of fine feed. In an experiment where green crops were fed exclusively, cows consumed 100 pounds per day of forage of such character as oats and peas.

6. Yearly records have shown that from three to four cows may be kept upon an acre for six months, beginning May 1st, the number depending upon the character of the season.

7. Records for five years show the average yield of milk and butter per cow, during the six months when forage crops were fed, to be 3,423 pounds and 172.7 pounds, respectively. The average percentage of fat in the milk was 4.32.

The same cows yielded an average of 3,050 pounds of milk and 157.4 pounds of butter, during the other six months of the year, when silage was fed. The average percentage of fat from the silage ration was 4.42.

1—*a.* A "home-grown" ration, composed of thirteen pounds of alfalfa hay and thirty pounds of corn silage, proved both practical and

economical when fed in comparison with a ration in which over two-thirds of the protein was derived from wheat bran and dried brewers' grains. Milk was produced from the home-grown ration for two-thirds the cost of that from the feed ration. The cost of milk per hundred was 55.9 cents against 83.9 cents for the feed ration.

b. The gain from feeding the home-grown ration, when milk is worth $1 per hundred, amounted to $1.99 per cow per month.

c. On the basis of this experiment, when mixed hay (timothy and red top) sells for $16 per ton, and wheat bran can be purchased for $26 per ton, and dried brewers' grains for $20 per ton, alfalfa hay is worth $24.52 per ton as a substitute for mixed hay, wheat bran and dried brewers' grains fed in the proportion indicated in the ration.

2—*a*. A second "home-grown" ration, composed of 16.4 pounds of crimson clover hay and thirty pounds of corn silage, proved a practical one from the feeder's standpoint, reducing the cost of milk 18.3 cents per hundred when fed in comparison with a ration in which the protein was largely purchased.

b. The gain from feeding this "home-grown" ration over the feed ration amounted to $1.10 per cow per month.

c. On the basis of this experiment, when wheat bran costs $26 per ton, dried brewers' grains $20 per ton and mixed hay (timothy and red top) $16 per ton, and when these feeds are used in the proportion indicated in the ration, crimson clover hay is worth $16.55 per ton as a substitute for the above foods.

3—*a*. A third "home-grown" ration, composed of thirty-six pounds of cow pea silage, ten pounds of crimson clover hay and six pounds corn and cob meal, costing 16.57 cents, produced as much milk as a ration in which over two-thirds of the protein was purchased in the form of dried brewer's grains and cottonseed meal and which cost 17.15 cents.

b. The results of this experiment are significant in showing that a ration composed of home-grown crops, though costing nearly as much (when the crops are figured at the market price), may be fully equal as a milk producer to a ration in which the protein is largely supplied by purchased feeds.

c. Home-grown crops were utilized in the dairy at a greater profit than could have been realized by selling them at the market price.

Soiling Crops, 1902.

The season of 1902 was characterized by an unusually cool temperature. Aside from this, it was particularly favorable to the growth of forage crops. With the exception of the month of May (precipitation 1.51 inches), the rainfall was well distributed throughout the growing season and no serious droughts occurred. Twelve kinds of forage were grown, alfalfa proving the most valuable on the basis of cost of production, yield and composition. The herd, including young stock, was equivalent to fifty full-grown animals. The arrangement of forage crops shown in Table I. furnished a continuous supply from May 1st until October 16th. About one and one-half tons of green forage were cut each morning to supply the herd for the day. This was fed to the cows in a two-acre field, into which they were turned every morning for exercise. The amount of forage fed varied according to the kind of fodder and the requirements of the animal. The average amount per day was sixty-one pounds per cow. In addition to the roughage used in summer, the cows received a feed ration, averaging 7.2 pounds per cow per day, of wheat brau, dried graius, malt sprouts and corn meal or rice meal, mixed in proportion to make a ration having a nutritive ratio of about 1.6.

A careful record was kept of the cost of producing each crop, time of cutting and seeding and the yield per acre. Data concerning crops grown in 1902 are contained in the following table:

TABLE I.

Cost and Yield of Soiling Crops.

Number of acre.	KIND.	Date of seeding.	Seed used—bushels.	Cost of— Labor.	Cost of— Seed.	Cost of— Fertilizer.	Period of cutting and feeding.	Yield—tons.	Total cost.
2	Rye	Oct. 10, 1901	4	$3 10	$2 40	....	May 1- 4	4.20	$5 50
2	Rye	" 2, 1901	4	6 20	2 40	....	" 4-16	11.31	8 60
2	Wheat	" 9, 1901	4	5 40	3 20	....	" 16-26	10.60	8 60
1.87	Alfalfa (first cutting)	May 23, 1901	1	....	....	$5 13	" 26-31	6.01	5 13
1	Alfalfa (first cutting)	" 14, 1898	7/12	....	....	2 48	" 31 to June 6	7.36	2 48
2	Peas and Oats	Mar. 26	{2½ 4}	6 00	6 00	5 54	June 6-14	12.04	17 54
2	Peas and Oats	April 14	{3 4}	7 80	6 74	5 54	" 14-21	10.44	20 08
2	Peas and Oats	" 17	{3 4}	4 50	6 74	5 54	" 21 to July 1	17.06	16 78
1.87	Alfalfa (second cutting)	....	....	....	....	....	July 1- 5	5.85	....
1	Alfalfa (second cutting)	....	....	....	....	....	" 5- 9	6.19	....
1	Mixed Grasses	....	....	....	....	....	" 9-14	6.70	....
5	Cow Peas	May 22	7½	14 40	16 88	12 50	" 14 to Aug. 6	42.80	43 78
1	Soy Beans and Sorghum (second crop)	June 4	{1 ½}	3 30	2 50	2 77	Aug. 6-10	7.25	8 57
1	Cow Peas and Sorghum (second crop)	" 4	{1 ½}	3 30	3 25	2 77	" 10-13	6.70	9 32
2	Barnyard Millet (second crop)	" 16	1½	6 60	2 04	5 68	" 13-22	20.01	14 32
1	Cow Peas (second crop)	" 9	2	3 30	4 50	3 61	" 22-28	12.00	11 41

TABLE I.—Continued.

Cost and Yield of Soiling Crops.

Number of acre.	KIND.	Date of seeding.	Seed used—bushels.	COST OF— Labor.	Seed.	Fertilizer.	Period of cutting and feeding.	Yield—tons.	Total cost.
1	White Flint Corn	May 9	¼	$1 20	$0 25	$2 77	Aug. 28 to Sept. 3	10.50	$7.22
1	White Flint Corn	June 18	⅓	5 25	33	2 30	Sept. 8-9	10.00	7 88
1	Corn (variety test, second crop)	" 18	⅓	4 50	33	4 55	" 9-20	14.14	9 38
2	White Flint Corn (second crop)	July 2	⅔	11 40	70	5 54	" 20 to Oct. 2	14.95	17 64
1	Southern White Corn	May 1	⅓	4 80	35	2 77	Oct 2-9	11.00	7 92
1	Cow Peas	July 8	2	3 15	4 50	2 77	" 9-18	6.41	10 46
2	Barley (third crop)	Aug. 19	8	3 15	2 50	5 54	" 13-16	8.56	11 19
	Total							257.00	

General Remarks Concerning Crops.

Rye and Wheat.—The cutting of rye began the 1st of May this season. Four acres were grown for soiling. The yield ranged from 2.1 tons to 6.55 tons per acre. The light yields were due to the rye being cut early, in order to seed the land to other crops.

Wheat followed rye, two acres producing 10.6 tons.

Alfalfa.—The acre of alfalfa sown May 14th, 1898, was cut five times this season, the yield at each cutting being as follows: June 2d, 7.36 tons; July 5th, 6.19 tons; August 6th, .49 tons hay, equivalent to 1.96 tons green forage; September 9th, 4 tons; October 15th, .60 tons. The total yield for the year was 20.11 tons of green forage. The following table shows the yield of alfalfa from this field and the cost per acre for five years:

TABLE II.

The Yield of Alfalfa and the Cost per Acre for Five Years.

	Seed—pounds.	Date of seeding.	Yield—Tons. Green forage.	Yield—Tons. Equivalent to hay.	Cost of— Labor. Seeding.	Cost of— Labor. Harvesting.	Cost of— Seed.	Cost of— Manures and fertilizers.	Total cost.
First year	80	May 14, 1898.	8.00	2.00	$8 65	*$1 92	$9 15	$23 65	$37 87
Second year			20.21	5.05		4 86		20 83	25 69
Third year			26.60	6.65		6 89		18 15	24 54
Fourth year			21.70	5.43		5 21		17 75	22 96
Fifth year			20.11	5.03		4 83		17 48	22 81
Total	80		96.62	24.16	$8 65	$23 21	$9 15	$97 86	$132 87
Average			19.32	4.83		4 64		19 57	26 57

* On hay basis.

Another field of alfalfa, consisting of 1.87 acres, was seeded in the spring of 1901. This plot yielded this season (1902) at the rate of 12.5 tons of green forage per acre.

Disking Alfalfa.

By disking alfalfa is meant the going over it in the spring, before growth starts, or in the summer, immediately after cutting, with a disk harrow. It is customary to set the disks at a slight angle. This cuts the crown roots and stirs the soil. Both our old alfalfa field and the one seeded last year were disked in August, this season, immediately after cutting the crop. The disking appeared to be beneficial to both fields, as it was followed by a vigorous growth and a general branching of the crown roots. Seed was sown where the alfalfa was thin, which, while it sprouted, was soon shaded and choked out by the growth of the old plants, except where the ground was nearly bare.

Crimson Clover.—This plant, which for six years has proved valuable in the forage rotation, was almost completely destroyed by the severe weather last winter.

Peas and Oats.—This season was particularly favorable for the growth of peas and oats. No serious drought occurred after the crop was well started, and the peas, as well as the oats, made a vigorous growth, especially those which were seeded about the middle of April. Six acres were grown, the yields ranging from 5.2 to 9 tons per acre.

Cow Peas.—The cow pea continues to be a valuable forage. It grows best on land that is free from weeds and, with a normal amount of rainfall, it is a sure crop. Seven acres were grown this year. The yields ranged from 6.41 to 12 tons per acre and averaged 8.74 tons.

Soy Beans.—A crop similar to the cow pea, but which does not yield quite as heavily. One acre was grown this season and the crop put in the silo, to be used in a feeding experiment.

Barnyard Millet.—A very desirable variety of forage, as it yields heavily and retains its palatability up to the time of blooming. It also has the characteristic of growing very rapidly, thus making a valuable crop for short rotations. Good yields have been secured at the College Farm in forty-five days. One acre treated with 160 pounds of nitrate of soda this season yielded 13.38 tons.

Corn.—A test was made with several varieties this season to study their value for forage. Two samples, designated in the test as "Ohio Yellow" and "Ohio White," were sent to the Station from that State; the variety "Parker's Mammoth Yellow" was secured from Illinois; the "Southern White" variety was obtained from Virginia; the "Mon-

Fig. 1.

Crop of Peas and Oats, season 1902. Yield, 9 tons per acre.

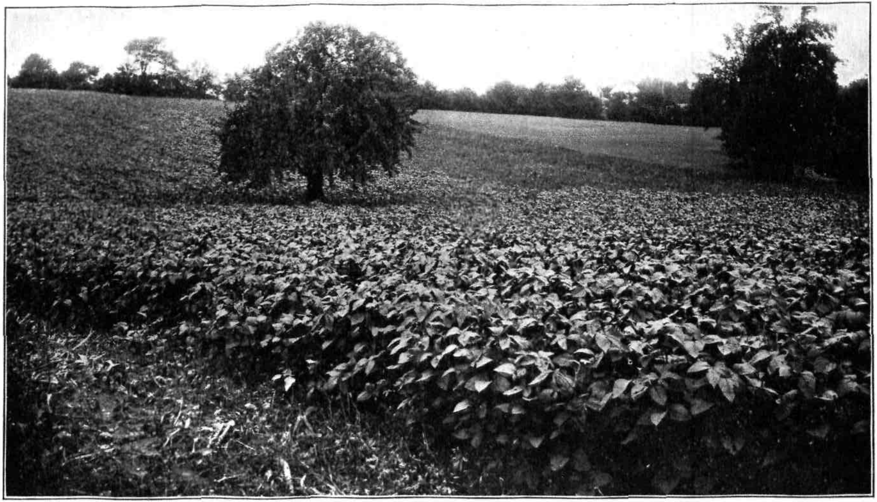

Fig. 2.

Crop of Soy Beans, season 1902.

mouth White" is a common variety in Monmouth county, this State, while the "Leaming" and "White Flint" have been grown on the College Farm for some years, and the seed used was taken from our own crop. The corn was planted June 18th in drills three and one-half feet apart and at the rate of ten quarts of seed per acre. One twenty-second of an acre was given to each variety. The yields are shown in the following table:

Yields of Different Varieties of Corn.

Variety.	State from which Seed was Obtained.	Yield per Plot, Pounds.	Yield per Acre, Tons.
Monmouth White	New Jersey...	1,480	16 28
White Flint	New Jersey...	1,350	14.85
Ohio White	Ohio	1,350	14.85
Southern White	Virginia	1,200	13.20
Parker's Mammoth Yellow	Illinois	1,190	13.09
Leaming	New Jersey...	1,125	12.38
Ohio Yellow	Ohio	950	10.45

It is noticeable that two New Jersey varieties are among the highest yielders, namely, "Monmouth White" and "White Flint," which produced at the rate of 16.28 and 14.85 tons per acre, respectively. The "Ohio White" yielded the same as the "White Flint," while the yield from the other varieties range from one and one-half to four tons less. The "White Flint" variety has been grown for forage at the College Farm for a number of years, with good results. Owing to its suckering habit, vigorous leafy growth and palatability, it is particularly well adapted for soiling. The "Ohio White," "Southern White" and "Parker's Mammoth Yellow" are coarser varieties and better adapted for the silo than for forage. The "Leaming," while not a heavy yielder for forage, is a very desirable variety for field corn.

Barley.—This is the latest forage fed in the fall. It has been our practice for the past three years to seed rye with barley in August or September and cut the barley the last of October. The rye holds over the winter and makes an early start in the spring. The plan has proven an excellent one, and four acres were treated in a similar way this season. To secure a good crop of barley it should be seeded as early as the first week in August.

Special Crops.

Soy Beans and Sorghum.—A combination of crops which has proved valuable in some localities. One acre was grown at the Station for the first time this year. Continued wet weather soon after seeding seemed to be unfavorable for the crop and growth was very slow. The acre yielded 7.25 tons.

Cow Peas and Sorghum.—A crop similar to the above. One acre was seeded at the same time and yielded 6.70 tons per acre. Further experiment is necessary to determine the value of both of these crops for forage.

Cow Peas and Corn as a Silage Crop.—A preliminary report on this combination of crops for the silo was given last year (1901). The statement was then made that the crop was cut with a corn harvester without any difficulty, and further, that the two crops passed readily through the silage cutter into the silo. Since the last report the silage from this crop has been fed to the dairy herd. It was in good condition and was much relished by all the animals.

Two acres of cow peas and corn were planted in a similar way this year, except that the cow peas were mixed with the corn and planted at the same time, while last year the peas were planted three weeks later. It is believed that a still better plan than either of these would be to plant the cow peas and corn the same date, but put them in separately—that is, with two operations. It was found that when the corn and peas were mixed before planting neither was distributed evenly. This is a very important part of the seeding.

Soiling Crop Rotations, 1902.

The arrangement of crops shown in Table III. furnished a continuous supply of forage for the dairy herd from May 1st until October 16th; the Dwarf Essex Rape on acres 1 and 2, the wheat on acres 3 and 4, and the rye on acres 5, 6, 15 and 17 to 22 were used for green manure. The total yield per acre for all crops in the year's rotation shows a profitable return. Leaving out of consideration the crops that were turned under, five acres yielded less than ten tons, ten acres yielded more than ten tons and less than fifteen, four yielded over fifteen and less than twenty, while two yielded over twenty tons. The average yield per acre for the crops in the year's rotation, not including those turned under, was 13.09 tons.

TABLE III.

Soiling Crops—Number, Kind and Acreage, 1902.

Number of acre.	CROP ROTATION.	Yield per acre.	Nutrients. Protein.	Nutrients. Ether extract.	Nutrients. Fiber and N. free extract.
		Tons.			
1	* Dwarf Essex Rape	.....	.....	.....	.....
	Peas and Oats	6.02	638.12	79.46	1,241.98
	Barnyard Millet	7.63	245.69	134.29	3,254.28
	Total	13.65	883.81	213.75	4,496.21
2	* Dwarf Essex Rape	.....	.....	.....	.....
	Peas and Oats	6.02	638.12	79.46	1,241.98
	Barnyard Millet	13.38	430.84	235.49	5,689.18
	Total	19.40	1,068.96	214.95	6,931.11
3	* Wheat	.....	.....	.....	.....
	Peas and Oats	5.22	553.32	68.90	1,076.89
	White Flint Corn	7.80	257.40	96.72	2,581.02
	Total	13.02	810.72	165.62	3,657.91
4	* Wheat	.....	.....	.....	.....
	Peas and Oats	5.22	553.32	68.90	1,076.89
	White Flint Corn	7.15	235.95	88.66	2,565.94
	Total	12.37	789.27	157.56	3,642.83
5	* Rye	.....	.....	.....	.....
	Peas and Oats	8.08	856.48	106.66	1,666.90
	† Soy Beans	4.70	267.90	51.70	1,281.22
	Total	12.78	1,124.38	158.36	2,948.12
6	* Rye	.....	.....	.....	.....
	Peas and Oats	9.00	954.00	118.80	1,856.70
	Cow Peas	6.41	869.22	98.71	1,282.00
	Total	15.41	1,823.22	217.51	3,138.70
7	Wheat	7.50	416.25	135.00	2,682.00
	Soy Beans and Sorghum	7.25	304.28	76.85	1,840.05
	Barley	1.20	64.80	14.40	379.20
	Total	15.95	785.28	226.25	4,901.25
8	Wheat	4.64	257.52	83.52	1,659.26
	Cow Peas and Sorghum	6.70	248.08	85.76	1,457.25
	Barley	2.36	127.44	28.32	745.76
	Total	13.70	669.04	197.60	3,862.27
9	Rye	6.56	339.95	78.60	2,397.30
	Corn (variety test)	14.14	466.62	175.34	4,678.98
	Total	20.69	806.57	253.94	7,076.28
10	Rye	4.76	247.04	57.12	1,742.16
	Cow Peas	12.00	691.20	184.80	2,400.00
	Total	16.76	938.24	241.92	4,142.16

* Used for green manure.

† Put in silo.

TABLE III.—Continued.

Soiling Crops—Number, Kind and Acreage, 1902.

Number of acre.	CROP ROTATION.	Yield per acre.	NUTRIENTS.		
			Protein.	Ether extract.	Fiber and N. free extract.
		Tons.			
11 {	Orchard Grass	1.83	95.16	32.94	786.90
	White Flint Corn	10.00	330.00	124.00	3,309.00
	Total	11.83	425.16	156.94	4,095.90
12—	Alfalfa	18.00	1,080.30	280.10	4,200.30
13—	Alfalfa	20.11	1,671.14	355.95	6,497.54
14—	Alfalfa	12.00	997.20	212.40	3,877.20
15 {	*Rye	......	......	......	......
	White Flint Corn	10.50	346.50	130.20	3,474.45
	Total	10.50	346.50	130.20	3,474.45
16 {	*Crimson Clover	......	......	......	......
	Southern White Corn	11.00	289.85	99.00	4,041.40
	Total	11.00	289.85	99.00	4,041.40
17-21 {	*Rye	......	......	......	......
	Cow Peas, (5 acres)	42.76	2.462.98	658.50	8,552.00
	Total	42.76	2,462.98	658.50	8,552.00
	Four tons clover hay contains		1,080	264	5,040
	Three " " " "		810	198	3,780
	Two " " " "		540	132	2,520
	Three tons wheat bran contains		924	246	3,240
	Three tons corn meal "		558	228	4,200

* Used for green manure.

A comparison of the amount of nutrients obtained per acre from the various combinations of crops, with that contained in clover hay, will give a better idea of their feeding value. For example, on acre No. 13 (alfalfa) the protein is equivalent to that contained in 6.2 tons of clover hay or 5.4 tons of wheat bran. On acres 5, 6 and 12 it is equivalent to that in more than four tons of clover hay; in 1, 2, 3, 10 and 14 to more than three tons; on 4, 7, 8 and 9 to over two tons and on the remaining eight acres to an average of 1.14 tons.

In nearly every case, the proportion of carbohydrates exceeds the proportion contained in clover hay, thus making the nutrients comparable with this crop. The nutrients contained in three tons of

wheat bran and corn meal, respectively, are also added in the table for comparison.

In eight acres, three crops are grown upon an acre in a year, but, with the exception of plots 7 and 8, the yield from only two crops is included, as the third crop was turned under. On ten acres two crops were grown, and in seven of these cases the first crop was turned under. On the remaining three acres only one kind of crop was grown. The actual yields, therefore, from thirteen of the twenty-one acres was larger than is indicated.

Practical Rotations for Soiling.

This line of work, which has now been in progress seven years, has proved valuable in showing the possibilities of intensive farm practice under good average conditions. Table IV. gives some rotations which have proved practical in respect to amount of nutrients as well as tonnage of green forage per acre. In many cases it has been possible to obtain as many as three crops per year of the regular summer forage crops, and as many as five cuts per acre of such perennials as alfalfa.

TABLE IV.

Some Practical Forage Rotations—Annual Yield Per Acre.

No. of acre.	Crops in one-year rotation.	Time of seeding.	Time of cutting.	Yield per acre. Tons.
1	Rye and Crimson Clover	September	May 1-10	8.05
	Oats and Peas	May 10	July 1-10	7.60
	Soy Beans	July 10	Sept. 1-10	9.00
	Total			24.65
2	Wheat Fodder	September	May 10-20	7.00
	Cow Peas	May 20.	July 10-20	8.20
	Japanese Millet	July 20	Sept. 10-20	7.00
	Total			22.20
3	Oats and Peas	April 1	June 10-20	7.34
	Japanese Millet	June 20	Aug. 1-10	8.73
	Barley and Peas	Aug. 10	Oct. 10-20	6.03
	Total			22.10

No. of acre.	Crop in one-year rotation.	Time of seeding.	Time of cutting.	Yield per acre. Tons.
4	Oats and Peas	April 10	June 1-10	6 80
	Cow Peas	June 10	Aug 10-20	8 20
	Barley and Peas	Aug. 20	Oct. 20-30	6.30
	Total			21.30
5	Rye	September	May 1-7	9.60
	Cow Peas	June 10	Aug 25-Sept. 1	10.50
	Barley	Sept. 2	Oct. 27-Nov. 1	2.60
	Total			22.70
6	Rye	October	May 7-19	9.60
	Soy Beans	June 10	Aug. 19-25	8.80
	Barley	Sept. 2	Oct 27-Nov. 1	2.60
	Total			21.00
7	Crimson Clover	July	May 20-June 1	8.00
	Corn	June 1	July 20-Aug. 1	9.56
	Total			17.56
8	Mixed Grasses	September	June 20-30	7.00
	Corn	June 20	Aug. 20-Sept. 1	12.24
	Total			19.24
9	Rye and Vetch	Sept. 10	May 10-19	8.60
	Corn	May 27	July 20-29	11.80
	Total			20.40
10	Rye	August	May 1-10	8.50
	Pearl Millet	May 18	Aug. 8-15	15.10
	Total			23.60
11	Oats and Peas	Aug. 10	June 16-23	10.20
	Cow Peas	Aug. 1	Sept. 16-22	8.00
	Total			18.20
12	Oats and Peas	Aug. 21	June 29-July 6	10.20
	Flint Corn	July 10	Sept. 22-30	11.00
	Total			21.20
13	Oats and Peas	April 2	June 26-July 4	6.20
	Cow Peas and Kaffir Corn	July 10	Sept. 1-16	12.20
	Total			18.40
14	Alfalfa—First year, two cuttings			8.00
	" Second year, four cuttings			20.21
	" Third year, five cuttings			26 60
	" Fourth year, four cuttings			21.70
	" Fifth year, five cuttings			20.11

What Constitutes Value in a Forage?

(1) YIELD AND COMPOSITION.

In the case of fine feeds the amount and quality of the nutrients they contain are taken as the basis in making a comparison of their feeding value. This method is also applicable in comparing the value of forage crops for milk production. The number of tons produced of any forage is not, in itself, a safe guide as to its value. For example, corn, at that stage of maturity which would make it a useful crop for feeding green, will contain about 25 per cent. of dry matter, whereas, certain millets, Kaffir corn, etc., belonging to the same group of plants, will oftentimes contain as little as 10 per cent. The same is true in the case of the leguminous crops; certain of these are much more watery at the proper stage for feeding than others. This point of variation of dry matter in the different crops should be taken into consideration, together with the other important one, namely, the influence of the proportion of the different nutrients in determining their value. For example, those crops which belong to the cereal group—corn, millet, sorghum, etc.—are carbonaceous in their character, and should be fed in connection with leguminous crops, which supply a larger amount of protein.

(2) SEASON OF THE YEAR IN WHICH THE CROP MAY BE GROWN AND TIME REQUIRED FOR IT TO MATURE.

There are certain winter annual plants, as rye, wheat and crimson clover, which are very valuable in the forage rotation from the fact that they are available in the early spring. Again, there are other crops which grow best, and can only be grown, in early or midsummer; among these may be mentioned oats and peas, cow peas and soy beans. Then there are others that are valuable for the reason that they will make considerable growth after the weather becomes cool, as barley, corn and certain of the grasses.

Other plants are valuable from the fact that they will mature in a very short period. In this class are included the various millets, the barnyard variety producing a crop in from forty to fifty days. The number of plants that will supply forage through the entire growing

season is very limited. Alfalfa comes as near to this as any we have had experience with. Cuttings from this crop have been made as early as May 12th and as late as October 22d.

(3) PALATABILITY AND INFLUENCE UPON THE FLAVOR OF MILK.

A plant that is not palatable is of but little value for forage. Fortunately there are not many that belong to this class. The following are not readily eaten by dairy stock: Yellow and Rural Branching Doura (Millo Maize) and Evergreen Broomcorn. Animals sometimes refuse to eat certain varieties of peas and beans for a short period, but they soon learn to like them. There is no forage crop which we have tested, with the exception of Dwarf Essex Rape, that has given an unpleasant flavor to milk when fed judiciously. This crop is not safe to feed to dairy cows. There is the most danger of producing a "grassy" flavor in milk at the beginning of the season, when animals are changed from dry foods to green forage. It sometimes occurs, also, when immature forage is fed. This undesirable effect can usually be overcome by feeding in limited quantities and *always after milking.*

Forage vs. Silage.

Inasmuch as the roughage in the rations for the dairy herd was composed largely of soiling crops from May 1st nntil November 1st, and of silage for the remaining six months, an opportunity is given for comparing the results from the two systems. Table V. shows the average yield of milk and the amount and percentage of butter fat produced by the herd for the past six years. Only those animals are included in this record which remained in the herd during the entire year.

The tabulation shows the average yield of milk per cow during the soiling and silage periods to be 3,457 pounds and 3,050 pounds, respectively, a difference of 407 pounds in favor of soiling. The average yield of butter was 173.8 pounds for the soiling period and 156 for the silage period, a difference of 17.8 pounds, also, in favor of soiling. The average percentage of fat for the two periods was practically the same, namely, 4.31 and 4.38. The number of fresh cows each month during the year was qnite uniform, hence the comparison

TABLE V.

Summary Record of the Dairy Herd, Showing Average Yields of Milk and Fat During the Soiling and Silage Periods.

YEAR.	Number of cows.	SOILING PERIOD. MAY 1ST—NOVEMBER 1ST. AVERAGE YIELD PER COW OF—				SILAGE PERIOD. NOVEMBER 1ST—MAY 1ST. AVERAGE YIELD PER COW OF—			
		Milk.	Fat.	Butter.	Fat.	Milk.	Fat.	Butter.	Fat.
		lbs.	lbs.	lbs.	%	lbs.	lbs.	lbs.	%
1897	21	3,414	144.5	168.6	4.28	2,941	123.1	143.6	4.18
1898	20	3,174	140.7	164.2	4.43	2,970	132.0	154.0	4.44
1899	12	3,889	164.8	191.7	4.23	3,078	137.8	160.8	4.48
1900	27	3,390	153.4	179.0	4.53	2,975	137.2	160.1	4.61
1901	26	3,250	137.1	160.0	4.22	3,287	144.2	168.2	4.39
1902	30	3,624	153.8	179.4	4.24	3,046	127.7	149.0	4.19
Average	22⅔	3,457	149.0	173.8	4.31	3,050	133.7	156.0	4.38

of yields for the two systems is a fair one, and shows that both systems are practicable in respect to the quantity, as well as the quality of the product produced.

Experiments with Nitrate of Soda on Rye, Wheat, Barnyard Millet and Barley.

Two acres were included in the experiment with each crop, one being treated with nitrate of soda as a top dressing, while the other, untreated, served in making the comparison. The objects of the experiment were (1) to study the effect of nitrate of soda upon the yield of the crop, and (2) to determine whether its use on forage crops was practicable from a financial standpoint. The following table shows the date and the amount of the application on the different crops and the yield from the treated and untreated plots.

TABLE VI.

KIND.	Date of application.	Amount of nitrate applied.	Date of cutting.	YIELD. Untreated acre.	YIELD. Treated acre.	GAIN. Tons.	GAIN. Per cent.	GAIN. Value at $3 per ton.	Cost of nitrate per acre.	Net gain over cost.
		lbs.		Tons.	Tons.					
Rye	April 1.	160	May 4-16.	4.76	6.55	1.79	37.6	$5 37	$3 88	$1 99
Wheat	" 1.	150	" 16-26.	4.64	7.50	2.86	61.6	8 58	3 38	5 20
Barnyard Millet	July 10.	160	Aug. 18-22.	7.63	13.38	5.75	75.4	17 25	3 60	13 65
Barley	Sept. 12.	160	Oct. 13-16.	1.20	2.36	1.16	96.6	3 48	3 60	— 12

The tabulation shows that the amount of nitrate applied on the different plots ranged from 150 to 160 pounds per acre. The gain in yield ranged from 1.16 tons, in case of the barley, to 5.75 tons for the barnyard millet. The percentage of gain ranged from 37.6 on the rye to 96.6 on the barley. The financial gain, which is the most important consideration, ranged from —12 cents on barley to $13.65 on millet. It should be stated, in connection with the experiment with barley, that the test was made very late in the season, when the growth was slow. It is reasonable to suppose that only a part of the nitrate applied was taken up by the crop, which yielded only 2.36 tons per acre, although this amount was nearly double that obtained from the untreated plot.

The results indicate that crops of this nature may be very materially increased by applications of nitrate of soda at the rate of 150 to 160 pounds per acre. They also show that the treatment is profitable from a financial standpoint, especially early in the season, when forage is not abundant.

Experiments with Lime on Cow Peas, Soy Beans and Forage Corn.

The object of these experiments was principally to study the effect of lime upon the yield of various forage crops, particularly where they had been grown continuously for a number of years without applications of lime. One acre was included in each experiment, one-half of which was treated with Corson's Prepared Lime, while the other half remained untreated. The following table gives the date and amount of the applications of lime and the yields from each plot:

Untreated plot. **Fig. 3.** Treated plot.

Experiment with Nitrate of Soda on Rye.

Untreated plot. **Fig. 4.** Treated plot.

Experiment with Nitrate of Soda on Wheat.

Treated plot. **Fig. 5.** Untreated plot.

Experiment with Nitrate of Soda on Barnyard Millet.

Fig. 6.

First Cutting of Alfalfa, season 1902.

TABLE VII.

	Acres.	Date of application.	Corson's prepared lime.	Date of harvesting.	YIELD PER ACRE		GAIN.	
					Untreated plot.	Treated plot.	Pounds.	Per cent.
			lbs.		lbs.	lbs.		
Cow Peas....................	½	July 8.	300	Oct. 9–12.	12,000	13,640	1,640	13.66
Soy Beans....................	⅙	" 8.	300	" 7.	8,800	10,000	1,200	13.64
Forage Corn..............	⅙	" 10.	300	Sept. 27—Oct. 8.	14,880	16,360	1,480	9.95

The tabulation shows a gain from the application of lime on all of the crops. The greatest increase was obtained on the cow peas and soy beans, which amounted to 13.66 and 13.64 per cent., respectively. The gain on the forage corn amounted to 9.95 per cent. In all cases the crops followed oats and peas, which yielded at the rate of 7.43 tons per acre. Hence, while the yields given in the above table are not large, the total yields from the two crops show profitable returns.

Cover Crops.

In addition to rye, wheat and crimson clover, which have been used at the Station as cover crops for a number of years, some new kinds were given a trial this year.

Crimson Clover and Cow-Horn Turnips.—This combination of crops has proven valuable elsewhere and was given a trial here this season. Two acres were seeded in corn August 2d, 1901 (at the time of last cultivation), at the rate of eleven pounds of crimson clover and two ounces of Cow-horn turnips per acre. The seed of both crops sprouted immediately and made a vigorous growth before frost. The Cow-horn turnip has the characteristic of penetrating deeply into the soil, hence it utilizes food which cannot be reached by shallow-feeding plants. Figure 8 shows the crop November 1st. The turnips, as well as the clover, had made considerable growth, and the crops at this time were more than sufficient to pay for the seed and labor involved. The clover did not withstand the winter. Corn was planted the following spring, and there was a noticeable difference between these two

acres and the plots adjoining, which were sown to clover only, the cover of turnips and clover combined producing corn richer and greener in color and a better yield.

Dwarf Essex Rape.—A crop not commonly used for cover, but which possesses some advantages over other crops. Its many prongs and long rootlets penetrate the soil in all directions, hence it is a gross feeder and draws heavily on the soil. The varieties of rape that are really valuable for forage or cover do not mature seed the same year that they are sown. Of these the Dwarf Essex variety is probably the best—in fact, it is about the only kind which has been thought worthy of cultivation in this country. Two acres of this variety were sown September 11th, 1901, after a crop of cow peas and Kaffir corn. The seed sprouted quickly and continued to grow until severe cold weather. As this crop has a different root system from cover crops commonly grown, it is believed to be a desirable practice to use it occasionally as a cover crop or in the forage rotation, to aid in gathering from the soil plant food which might not otherwise be utilized.

Cost of Producing Milk.

Beginning April 1st, 1896, records have been kept of the cost of labor, the kind, amount and cost of foods eaten by the dairy herd and the amount of milk produced by each cow. The cost of producing milk in previous years has been published in the annual reports. The cost for the year ending April 1st, 1902, is here reported. The herd averaged thirty cows.

Fig. 7.
A Cover Crop of Crimson Clover and Cow-Horn Turnips.

TABLE VIII.

The Kind, Amount and Cost of Foods for Thirty Cows for One Year, April 1st, 1901, to April 1st, 1902.

	Amount Fed. lbs.	Cost per Ton.	Total.	
Wheat bran	24,000	$19 90	$238 80	
Dried grains	24,000	18 50	222 00	
Malt sprouts	3,000	20 20	30 30	
Buckwheat middlings	4,000	17 20	34 40	
Linseed meal	2,000	34 00	34 00	
Cottonseed meal	6,000	30 00	90 00	
Rice meal	4,800	20 45	49 08	
Corn meal	12,000	22 65	135 90	
Cost of feeds				$834 48
Soiling crops	314,000	1 60	251 20	
Silage	204,000	2 40	244 80	
Dried cornstalks	13,200	4 00	26 40	
Hay	21,600	5 00	54 00	
Roughage				$576 40
Total cost of food				1,410 88

Total cost of food	$1,410 88	
Cost per cow per day		12.88 cents.
Cost of feeds	834 48	
Cost per cow per day		7.62 cents.
Cost of roughage	576 40	
Cost per cow per day		5.26 cents.
Total yield of milk	87,754 quarts.	
Average per cow per day		8.01 "
Cost of food per quart		1.61 cents.
Cost of feed per quart		.95 "
Cost of roughage per quart		.66 "

The cost of feeds represents what was actually paid. The cost of hay, cornstalks and soiling crops represents the actual cost of labor, seed, manures and fertilizers, the farm manure being charged at the rate of $1.50 per ton. Fifteen of the twenty-two forage acres received a dressing of manure at the rate of seven tons per acre.

The average cost of the dairy ration was 12.88 cents, of which 7.62 cents, or 59.2 per cent., is due to purchased feeds and 5.26 cents, or 40.8 per cent., to the cost of farm crops. The total cost of producing milk, including the cost of labor and the interest on, and decrease in, the value of the herd, are given, the latter item being estimated.

TOTAL COST OF PRODUCING MILK.

Foods as per statement		$1,410 88
Labor	$600 00	
Interest on value herd at 5 per cent	60 00	
Decrease on value herd at 5 per cent	60 00	
		$720 00
Total		$2,130 88
Cost of food per quart of milk		1.61 cts.
Cost of labor and interest per quart of milk		.82 "
Total cost per quart		2.43 "

The average weight per quart of milk, as put up in bottles for delivery, was 2.18 pounds; hence, the total weight of milk, 191,304 pounds, was equivalent to 87,754 quarts. The cost per hundred was, therefore, $1.11. At $1 per hundred, the price received in rural districts, the profits from the business, if any, must be in the manure. In the calculation of the cost of farm foods the manure was charged at the rate of $1.50 per ton. The amount produced by the herd during the year was 330 tons. In selling milk at $1 per hundred the receipts are $217.84 less than the expenses. Deducting this amount from the actual charges made for manure, in the growing of the crops—$1.50 per ton—there remains $277.16, which represents the profits from thirty cows, an amount too small to make the business pay. In rural districts, however, where pasture is abundant, the cost of food would not be as great as where soiling crops supply the entire ration, with the exception of concentrates.

At 3½ cents per quart, the price that could have been received at wholesale, the receipts would have amounted to $3,071.39. Deducting the cost of purchased feeds, labor and interest and decreases in the value of the herd, amounting to $1,554.48, we have a balance of $1,516.91, which represents the value of the home-grown product; or, in other words, at 3½ cents per quart for milk, the farm would sell its produce to the dairy at profitable prices, namely, $4.21 for soiling crops, $6.32 for silage, $13.16 for hay and $10.53 per ton for dried corn stover, a gain on the crops over cost of production of $2.61 per ton for soiling crops, $3.92 for silage, $8.16 for hay and $6.53 for dried corn stover, besides an additional gain represented by 330 tons of manure.

Looking at the question of profit from another standpoint, we will assume that the dairyman performs the work himself. Deducting, therefore, the item of labor, which amounted to $600, from the total

cost of production ($2,130.88), we have a balance of $1,530.88. Dividing this amount by the total pounds of milk produced (191,304), we find the cost per hundred to be 80 cents. The difference, therefore, between the cost and selling price of the milk represents the dairyman's profits when he performs the work himself.

Assuming that the milk produced by the above thirty cows had been sold for $1 per hundred, a profit of 20 cents would have been realized from every hundred pounds, or a total of $382.61 for the year's production, besides the additional gain represented by the 330 tons of manure. At 3½ cents per quart the profits would have amounted to $1,541.51, besides the additional gain from the manure.

TABLE IX.

Average Cost of Producing Milk for Six Years.

YEAR.	Number of cows.	MILK PRODUCED. Pounds.	MILK PRODUCED. Quarts.	Average yield per cow.	COST PER COW PER DAY. Feeds.	COST PER COW PER DAY. Roughage.	COST PER COW PER DAY. Total	COST PER QUART OF MILK OF— Feeds.	COST PER QUART OF MILK OF— Roughage.	COST PER QUART OF MILK OF— Labor and interest.	COST PER QUART OF MILK OF— Total.
				lbs.	cts.	cts.	cts.	cts.	cts.	cts	cts.
1896	23	141,517	64,916	6,153	4.99	6.61	11.60	.646	.856	.99	2.49
1897	25	154,768	70,990	6,191	5.06	6.38	11.44	.650	.820	.92	2.39
1898	25	172,726	79,232	6,911	6.53	6.16	12.69	.750	.710	.82	2.28
1899	30	198,345	90,984	6,612	6.65	6.58	13.23	.800	.790	.79	2.38
1900	30	195,875	89,851	6,529	7.30	5.35	12.65	.890	.650	.80	2.34
1901	30	191,304	87,754	6,377	7.62	5.26	12.88	.950	.660	.82	2.43
Average	......	175,756	80,621	6,462	6.36	6.06	12.42	.781	.748	.86	2.39

The average production per year for the six years is shown to be 175,756 pounds, equivalent to 80,621 quarts. The average yield per cow was 6,462 pounds. The average cost of food per cow per day was 12.42 cents, of which 6.36 cents, or 51.2 per cent., was due to purchased feeds, and 6.06 cents, or 48.8 per cent., to the cost of farm crops. The average cost per quart of milk for the six years, including food, labor and interest and decrease in the value of the herd, is shown to be 2.39 cents.

The Dairy Business in Relation to Soil Exhaustion.

The following table shows the amount of fertilizing elements contained in the feeds purchased and in the milk produced by a herd of twenty-three cows in 1896, twenty-five cows in the years 1897 and 1898 and thirty cows in 1899, 1900 and 1901.

The above table shows a decided gain to the farm in fertility elements during all six years. The total gain is equivalent in nitrogen and phosphoric acid to that contained, respectively, in twenty-three tons of nitrate of soda and twenty-five tons of acid phosphate, and in potash to that contained in 2.18 tons of high-grade muriate of potash. *It is not affirmed that the constituents contained in the manure are* equal in agricultural value to those contained in the fertilizers mentioned, or that, even under the best conditions of care and application, they could all be used by the plants, but, because the manure contains all the constituents and is well adapted for most crops, the general farmer is, as a rule, able to get as good returns from it, in proportion to constituents contained, as from products containing the same constituents in more available forms.

The tabulation shows that if all the milk sold from the farm was obtained from foods grown on the farm, the exhaustion of nitrogen would be in greater proportion than the mineral elements, and that, when this is the practice, it is necessary to apply nitrogenous fertilizers in order to maintain the fertliity. If manure is well cared *for and used properly, it is more economical to purchase the nitrogen* in the form of feeding stuffs, whose whole cost is returned in the increased product resulting from the use of well-balanced rations.

TABLE X.

KINDS.	AMOUNT.						NITROGEN.						PHOSPHORIC ACID.						POTASH.					
	1896.	1897.	1898.	1899.	1900.	1901.	1896.	1897.	1898.	1899.	1900.	1901.	1896.	1897.	1898.	1899.	1900.	1901.	1896.	1897.	1898.	1899.	1900.	1901.
	tons.	tons.	tons.	tons.	tons.	tons.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs	lbs	lbs.	lbs.	lbs.	lbs	lbs	lbs	lbs.	lbs.	lbs	lbs.
Wheat Bran	9.40	12.50	14.50	15.85	17.00	12.00	460	612	710	777	833	688	545	725	841	919	986	691	301	402	464	507	544	391
Dried Brewers Grains	9.20	8.15	10.25	13.75	13.06	12.00	662	587	838	990	940	864	202	179	226	308	287	264	15	13	17	22	21	19
Corn Meal	6.10	8.30	5.00	7.05	7.50	6.00	201	109	165	233	248	198	85	46	70	99	105	84	49	26	40	56	60	48
Linseed Meal	3.55	4.45	3.50	1.05	.90	1.00	377	478	372	111	95	107	126	158	124	38	32	88	97	121	96	29	24	28
Malt Sprouts	.....	.....	.....	.....	.....	1.50	.....	.....	.....	.....	.....	124	.....	.....	.....	.....	.....	49	.....	.....	.....	.....	.....	56
Cottonseed Meal	.....	.....	.....	1.75	4.50	8.00	.....	.....	.....	238	612	406	.....	.....	.....	106	275	180	.....	.....	.....	66	171	114
Rice Meal	.....	.....	1.75	2.70	.....	2.40	.....	.....	69	105	.....	94	.....	.....	94	145	.....	129	.....	.....	25	89	.....	85
Pea Meal	.....	.....	.....	.....	1.00	.....	.....	.....	.....	.....	32	.....	.....	.....	.....	.....	16	.....	.....	.....	.....	.....	20	.....
Buckwheat Feed	.....	.....	.80	1.60	.....	2.00	.....	.....	36	29	.....	179	.....	.....	18	53	.....	88	.....	.....	13	42	.....	46
Total or gain in feeds	.....	.....	.....	.....	.....	.....	1700	1781	2190	2483	2760	2560	958	1108	1378	1668	1701	1526	462	562	656	761	840	787
Sold in Milk	70.86	77.38	86.86	99.17	97.94	95.65	849	927	1036	1190	1173	1146	318	347	389	446	440	429	248	271	302	317	343	385
Gain to Farm	.....	.....	.....	.....	.....	.....	851	854	1154	1293	1587	1414	640	761	984	1222	1261	1099	214	291	353	424	497	402
Total gain in six years	.....	.....	.....	.....	.....	.....	7,158						5,967						2,181					

Experiences with Parturient Paresis (Milk Fever).

The remarkable results obtained by the use of the Schmidt treatment for milk fever have led us to give our experience here. Inasmuch as the disease is well known to most dairymen, a detailed description of it is not essential. The necessary outfit for this treatment is not expensive. It requires a three-inch funnel, four or five feet of one-fourth inch rubber tubing and a small glass pipette or milking tube. The method of procedure which we have used is similar to that recommended by the Maryland Experiment Station in Bulletin No. 76, which is as follows:

(1) Dissolve 120 grains of iodide of potash in one quart of water, which has been boiled and allowed to cool to about the temperature of the body.

(2) Introduce the funnel and pipette into the ends of the rubber tube and place in a bucket of antiseptic fluid.

(3) Milk the udder dry, then place under the cow a piece of oilcloth, about a yard square (a carriage storm-apron may be made to answer), so that the udder will be about the middle of the cloth. Wash the udder and teats thoroughly with castile soap and warm water, rinsing carefully with antiseptic fluid.

(4) Insert the pipette into the end of a teat and fill the funnel with iodide of potash solution. By passing successively from one teat to another, distribute the solution equally among the quarters of the udder.

(5) Rub the udder from the teat towards the body and massage thoroughly, in order to distribute the solution throughout.

(6) Eight or ten hours after the injection, or when recovery is assured, the udder should be carefully milked out and then bathed with warm water (about 160 degrees Fahrenheit).

A second injection is rarely necessary; but, if so, it should be done at the end of six or eight hours.

If there should be a tendency toward hardness of the udder or "stringiness" of the milk, baths of warm water should be applied every three or four hours until relieved. If neglected, Mastitis (Garget) will result.

Prevention.—As a preventive measure it is advisable to restrict robust animals to a moderate allowance of dry food for a week or ten days previous to the end of their term; and, where there is a tendency toward costiveness or constipation, correct it with a drench of Epsom salts.

Fig. 8.

Zola—Cow Cured of Milk Fever by "Schmidt Treatment."

Fig. 9.
Filling the Silo

Formulæ for Solution.

Iodide of Potash Solution:

Iodide of Potash (crystals)	120 grains.
Water (previously boiled)	1 quart.

(When thoroughly dissolved inject into the udder as described).

Drench for Costiveness:

Epsom Salts	1 pound.
Ground Ginger	1 ounce.
Water (tepid)	3 pints.

(Give at one dose, administered slowly).

Antiseptic Solutions:

Creolin	1 part.
Water	30 parts.
Thymo-Cresol	1 part.
Water	30 parts.
Chloro-Naphtholeum	1 part.
Water	30 parts.

Any of these antiseptic solutions will answer for this treatment.

In four cases treated at the Station, as here indicated, three recovered. Of these one developed "stringiness" of milk, which was soon corrected.

Description of Milk Fever Cases.

Zola.—A cow five years old, calved on the afternoon of September 20th, and was given a drench immediately for costiveness, after which she appeared to be all right. Milk fever developed, however, on the morning of the 22d, and at seven o'clock the cow was down and unable to move. Iodide of potash was injected according to directions given above, and in one hour the animal showed signs of recovery, and at twelve o'clock, five hours after the treatment, she was standing up and eating. A little "stringiness" developed in the milk, which disappeared in a few days. A photograph of the cow is shown in Figure 9.

Princessa.—Six years old, calved May 22d, at noon. The following day she began to stagger about the stall and show signs of milk fever. In the course of an hour she became exhausted and lay prostrated in the stall, unable to raise her head. The Schmidt treatment was applied, and in fifteen minutes after the injection the cow was standing and a half hour later began to eat.

Cherry.—Calved January 1st and showed signs of milk fever the following day. The injection was made before the animal got down and recovery began immediately.

Woodlawn.—Calved May 15th and was taken with a severe attack of milk fever in the early morning of the 16th. This was well developed before discovered and complications set in in the form of digestive disturbances of the stomach and intestines, which caused constant bloating, although the trochar was used repeatedly. The Schmidt treatment was applied, but in spite of all efforts to relieve her, the animal died at six o'clock. The cow was old, which perhaps accounts for the disease being fatal in this case, as records show more fatalities among older animals.

RECORDS OF THE DAIRY HERD, APRIL 1ST, 1901, TO APRIL 1ST, 1902.

Beginning April 1st, 1896, complete records have been kept of the dairy herd, including the yield and composition of the milk of individual animals. These records have been published annually in the Station Reports.

The herd consists largely of grade animals—one Guernsey, three Holsteins and three Ayrshires are pure bred. Twenty-two animals remained in the herd throughout the entire year, and their records are given in the tabulation. Many of the cows giving the lower records have been valuable animals in past years, but have become unprofitable, and some have already been removed from the herd. The average, however, for the herd was 6,671.1 pounds.

As already shown under "Cost of Producing Milk," the foods consumed were only such as to provide a sufficient and well-balanced ration. Soiling crops were fed for practically six months, and silage the remainder of the year. In connection with the weight of the milk, which was taken daily, the product from each cow was sampled and analyzed once in two weeks. The accompanying table shows the monthly yield of milk and its composition, as well as the total yield per cow of milk, of fat and of butter. The butter equivalent is derived from the fat by adding one-sixth.

TABLE XI

Record of the Dairy Herd.

Name of cow.		April.	May.	June.	July.	August.	September.	October.	November.	December.	January.	February.	March.	Total yield.	Average per cent. of fat.	Total fat.	Equivalent to butter.
Viola	Pounds of Milk	598.7	686.7	568.0	303.5	25.8	....	201.4	941.7	981.6	885.2	686.8	823.4	6,652.8	3.97	263.89	307.99
	Per Cent. of Fat	3.9	4.0	4.1	5.1	4.9	....	4.0	4.2	3.7	3.9	3.7	3.8	....	......	....	....
Hilda	Pounds of Milk	256.1	....	495.7	1,338.6	1,208.2	1,047.8	1,131.3	843.7	1,068.4	967.7	704.8	780.2	9,782.0	3.75	366.39	427.46
	Per Cent. of Fat	4.9	....	4.2	3.5	3.4	3.7	3.8	3.4	3.9	4.8	3.9	4.1	....	......	....	....
Model	Pounds of Milk	1,084.4	1,145.7	1,048.5	793.5	709.7	688.8	728.2	646.7	516.7	404.6	252.4	68.3	7,982.5	4.53	361.31	421.58
	Per Cent. of Fat	4.3	4.2	4.1	3.9	4.6	4.1	3.9	4.8	4.1	4.5	4.7	4.2	....	......	....	....
Select	Pounds of Milk	....	977.6	1,429.6	1,042.2	841.1	750.7	811.4	722.4	601.9	721.1	532.8	373.8	8,804.6	4.36	383.90	447.88
	Per Cent. of Fat	....	4.2	4.6	4.4	3.7	4.3	4.2	4.3	4.7	4.4	4.5	5.0	....	......	....	....
Gipsey	Pounds of Milk	948.9	1,080.0	923.8	707.5	657.1	548.8	366.2	46.4	....	....	112.1	1,150.6	6,490.9	4.13	267.92	312.57
	Per Cent. of Fat	3.9	4.1	4.0	3.9	3.9	4.8	4.7	4.7	....	....	4.0	4.2	....	......	....	....
Pearl	Pounds of Milk	536.7	487.4	853.7	94.8	857.9	842.0	872.8	758.0	820.2	682.5	514.9	628.4	6,939.8	4.43	307.55	358.81
	Per Cent. of Fat	4.4	5.1	5.1	5.6	5.6	4.2	4.1	3.9	4.2	4.2	4.3	4.8	....	......	....	....
Woodlawn	Pounds of Milk	....	....	390.0	1,177.2	938.6	843.8	878.8	762.1	702.8	569.5	286.2	43.0	6,586.0	3.86	254.23	296.60
	Per Cent. of Fat	....	....	4.0	3.4	3.4	4.2	3.7	3.9	4.2	4.4	4.4	4.6	....	......	....	....
Victoria	Pounds of Milk	1,278.3	1,313.7	1,116.8	875.1	785.2	754.8	745.7	629.7	652.7	690.7	618.9	601.9	9,963.5	3.61	359.62	419.56
	Per Cent. of Fat	3.2	3.6	3.7	4.2	3.4	3.8	3.8	3.8	3.4	4.4	3.5	3.7	....	......	....	....

TABLE XI.

Record of the Dairy Herd—*Continued.*

Name of cow.		April.	May.	June.	July.	August.	September.	October.	November.	December.	January.	February.	March.	Total yield.	Average per cent. of fat.	Total fat.	Equivalent to butter.
Zola	Pounds of Milk......	515.0	428.3	269.5	144.1	29.6	638.8	1,046.9	842.1	944.7	826.1	663.5	712.8	7,061.4	4.03	284.48	331.84
	Per Cent. of Fat.....	4.9	4.9	4.4	4.2	4.2	4.4	3.8	3.7	3.8	3.8	4.0	4.4	......	......	......	......
Blue	Pounds of Milk......	881.0	884.1	818.0	639.9	523.3	226.9	......	......	......	945.2	1,129.1	1,075.0	7,072.5	4.37	309.42	360.99
	Per Cent. of Fat.....	4.2	4.4	4.6	4.7	4.6	5.1	......	......	......	3.6	4.7	4.2	......	......	......	......
Raritan......	Pounds of Milk......	242.5	1,008.4	990.6	761.2	670.6	680.5	519.2	851.2	90.1	......	......	1,030.5	6,287.8	4.11	258.58	301.68
	Per Cent. of Fat.....	3.1	4.0	4.1	4.0	3.9	4.2	4.1	4.1	4.2	......	......	4.4	......	......	......	......
Genesta.....	Pounds of Milk......	1,075.7	1,044 6	959.8	746.1	648.1	559.8	519.1	229.8	......	......	......	......	5,782.5	4.19	242.18	282.49
	Per Cent. of Fat.....	3.9	4.4	3.9	4.2	3.7	4.7	4.3	5.6	......	......	......	......	......	......	......	......
Luella........	Pounds of Milk......	896.8	1,018.8	967.6	728.1	626.5	557.6	451.5	426.6	342.2	286.6	41.1	......	6,332.4	4.66	294.92	344.07
	Per Cent. of Fat.....	4.5	4.8	4.5	4.6	4.1	5.6	5.1	5.5	4.7	5.9	6.7	......	......	......	......	......
Roma........	Pounds of Milk......	840.8	448.6	861.1	114.4	......	......	......	498.4	1,115.9	880.0	649.9	720.1	5,065.7	4.37	221.18	257.99
	Per Cent. of Fat.....	4.2	4.2	4.5	5.6	......	......	......	4.5	4.4	4.6	4.2	4.0	......	......	......	......
Daisy	Pounds of Milk......	715.6	747.8	704.0	553.6	446.5	422.8	339.2	266.9	187.5	19.5	......	576.5	5,029.9	5.52	277.50	323.75
	Per Cent. of Fat.....	6.1	5.8	5.8	4.9	5.1	6.0	6.2	5.5	6.5	6.5	......	5.7	......	......	......	......
Evesta, 5th..	Pounds of Milk......	487.4	485.8	872.6	291.6	240.0	49.2	......	......	......	801.8	652.2	564.7	3,845.3	4.26	163.80	191.10
	Per Cent of Fat.....	4.2	4.2	3.8	4.4	4.7	4.6	......	......	......	4.6	3.9	4.3	......	......	......	......

TABLE XI.

Record of the Dairy Herd—Continued.

Name of Cow.		April.	May.	June.	July.	August	September.	October.	November.	December.	January	February.	March.	Total yield.	Average per cent. of fat.	Total fat.	Equivalent to butter.
Cherry	Pounds of Milk	....	....	27.6	1,099.8	988.9	811.8	790.7	683.9	566.5	498.9	335.8	200.7	5,958.6	4.41	262.79	306.59
	Per Cent. of Fat	....	....	5.4	4.8	3.9	4.4	4.5	4.0	4.3	4.6	4.4	5.6	....	....	....	....
Regena	Pounds of Milk	356.4	272.8	47.8	....	399.3	731.3	758.4	579.0	462.6	443.6	340.6	299.3	4,676.6	3.95	184.94	215.76
	Per Cent. of Fat	4.8	4.5	4.8	....	3.8	3.9	3.4	3.5	4.6	4.0	3.8	4.6	....	....	....	....
Ideal	Pounds of Milk	718.2	697.0	695.8	498.5	412.0	382.9	176.7	....	854.9	875.7	674.9	747.2	6,978.8	4.58	302.76	353.22
	Per Cent. of Fat	4.3	4.9	4.7	4.7	4.8	6.0	6.0	....	4.8	3.9	4.1	4.4	....	....	....	....
Queen	Pounds of Milk	1,422.8	1,419.6	1,207.2	818.1	680.8	671.0	712.2	455.6	278.2	18.2	....	1,178.4	8,857.1	4.07	360.22	420.26
	Per Cent. of Fat	4.1	4.5	3.6	4.1	3.7	4.2	4.3	4.0	4.4	4.4	....	3.9	....	....	....	....
Alta	Pounds of Milk	785.2	720.6	642.6	551.6	459.4	224.4	....	....	....	....	486.9	1,041.3	4,862.0	3.80	184.93	215.75
	Per Cent of Fat	3.7	3.7	3.6	4.1	4.0	4.9	....	....	....	....	3.8	3.6	....	....	....	....
Sebolt	Pounds of Milk	526.8	473.1	355.9	196.1	11.5	677.9	750.3	678.8	648.1	659.4	551.8	544.2	6,067.9	4.61	279.65	326.26
	Per Cent. of Fat	4.6	5.2	4.5	4.5	4.5	4.3	4.5	4.2	4.4	4.7	4.9	5.1	....	....	....	....
	Average	....	....	....	....	....	....	....	....	....	....	....	....	6 671.1	4.22	281.40	328.97

In a herd of grade cows, representing several breeds, it is natural that there should be a wide variation both in the yield and composition of the milk produced by the individual animals. While there are two distinct classes of dairy cows, viz., milk producers and butter producers, there are also many animals of mixed breeding which combine these two characteristics in a remarkable degree. This point is clearly brought out in the following tabulation: 1. Yields of Milk; 2. Yields of Butter; 3. Yields of Milk and Butter from animals which combine, in a marked degree, the qualities of milk and butter prodnction.

1. Yields of Milk.

1 cow....	.....an average of more than	3,000 lbs.	and less than	4,000 lbs.
2 cows........	" "	4,000 "	"	5,000 "
4 "	" "	5,000 "	"	6,000 "
8 "	" "	6,000 "	"	7,000 "
3 "	" "	7,000 "	"	8,000 "
2 "	" "	8,000 "	"	9,000 "
2 "	" "	9,000 "		

The best cow produced....................................	9,953.5 lbs.
The poorest cow produced..................................	3,845.3 "
Difference between highest and lowest....................	6,108.2 lbs.
Average per cow..	6,671.1 "

2. Yields of Butter.

1 cow..............	an average of more than	150 lbs.	and less than	200 lbs.
2 cows............	" "	200 "	" "	250 "
3 "	" "	250 "	" "	300 "
8 "	" "	300 "	" "	350 "
3 "	" "	350 "	" "	400 "
5 "	" "	400 "	" "	

The best cow produced....................................	447 lbs.
The poorest cow produced..................................	191 "
Difference between highest and lowest....................	256 lbs.
Average per cow..	328 "

3. Yields of Milk and Butter.

From animals which combine, in a marked degree, the qualities of both milk and butter production.

Name.	Breed.	Yield of Milk. lbs.	Yield of Butter. lbs.	Fat. %
Ideal	Grade Holstein	6,678	353	4.53
Pearl	" "	6,939	358	4.43
Zola	" "	7,061	331	4.03
Blue	" "	7,072	360	4.37
Model	" Jersey	7,982	421	4.53
Select	" Shorthorn	8,804	447	4.36
Queen	" Holstein	8,857	420	4.07
Hilda—Pure Bred	"	9,782	427	3.75
Victoria	Grade "	9,953	419	3.61

It has been shown that the cost of rations per cow per day was 12.88 cents, or a total of $47.01 per year. Following the same line of comparison, the advantages of the better cows are shown in the following tabulation:

	At 1 cent per lb.	At 3 cents per qt.	Cost of Food.	Gain over Food. At 1 cent per lb.	Gain over Food. At 3 cents per qt.
Average value of product of 15 cows, yielding more than 6,000 lbs. of milk.	$74 36	$102 36	$47 01	$27 35	$55 35
Average value of product of the 7 cows, yielding less than 6,000 lbs. of milk	50 30	69 21	47 01	3 29	22 20
Value of product of average cow	66 71	91 80	47 01	19 07	44 79

At 1 cent per pound, the yield of the fifteen cows, producing more than 6,000 pounds of milk, is sufficient to pay for their food and $27.35, besides manure, while the average yield of the seven cows, producing less than 6,000 pounds of milk, is sufficient to pay for their food and only $3.29, besides manure; a difference of $24.06 in favor of the better cows. At 3 cents per quart, the returns from the cows yielding over 6,000 pounds of milk, over cost of food, are increased to $55.35, while for the cows yielding less than 6,000 pounds they are increased to $22.20, or less than one-half of those of the better cows at 1 cent per pound.

The facts brought out by this study indicate that but little profit

can be derived from a cow that does not produce 5,000 pounds of milk per year, particularly if the milk is sold at the low price of 1 cent per pound. No stronger argument is needed in favor of the necessity *of testing the animals, and thus learning their exact value, than is* afforded by the above records.

When butter is made, practically all the fertilizing elements in the whole milk remain upon the farm, and these, together with the feeding value of the skim-milk, which is estimated by careful dealers to be 20 cents per hundred, is an offset against the extra labor in making butter.

	20 cts. lb.	Foods.	Gain over Food.
Average value of product of the 16 cows, yielding over 300 lbs. of butter	$72 06	$47 01	$25 05
Average value of product of the 6 cows, yielding less than 300 lbs. of butter	48 86	47 01	1 85
Value of product of average cow	65 67	47 01	18 66

The tabulation shows that the sixteen cows, yielding over 300 pounds of butter, paid for their food and $25.05 in addition to skim-milk and manure, while the manure and skim-milk of the six cows, yielding less than 300 pounds of hutter, represent the pay received for their care and the labor of making the butter, with $1.85 additional. The facts brought out by the above records indicate that there is but little profit from a cow that does not produce 200 pounds of butter per year, *and point to the necessity of a careful selection of cows for* the butter dairy.

Average Analyses of Herd Milk.

It was desired at the outset to build up a herd that would produce milk containing at least 4 per cent of butter fat. The average per cent. in the herd milk has exceeded this amount each year, as shown by *the following:*

1897	4.25	per cent.	fat.
1898	4.44	"	"
1899	4.50	"	"
1900	4.57	"	"
1901	4.33	"	"
1902	4.39	"	"

Wastes in Handling and Delivery.

A careful record has been kept of the amount of milk wasted in handling, cooling and delivering. The waste during the past six years is shown in the following tabulation:

	Waste in Handling, Cooling and Bottling. per cent.	Waste in Delivery or Dippage. per cent.	Total Waste, per cent.
1897	5.7	5.1	10.8
1898	4 4	4.9	9.3
1899	4.8	2.0	6.0
1900	4.7	1.7	6.4
1901	3.8	1.7	5.5
1902	.8	1.2	2.0

During the years 1897 and 1898 about 50 per cent. of the milk was bottled, so that the actual loss due to dippage was practically 10 per cent. For the past four years the proportion of milk delivered in bottles has been gradually increased and the waste this year was reduced to 1.2 per cent. While the use of bottles increases the expense of delivery, due to extra weight on the wagon, the extra work of cleaning and the breakage and loss of bottles, which amounted to 10 cents per day per hundred bottles, the decrease in waste, greater cleanliness and better condition of the milk when delivered, has more than offset this extra cost. The tabulation also shows that there has been a decrease from year to year in the percentage of waste in handling, cooling and bottling. This is due largely to improved apparatus and greater care in handling the product.

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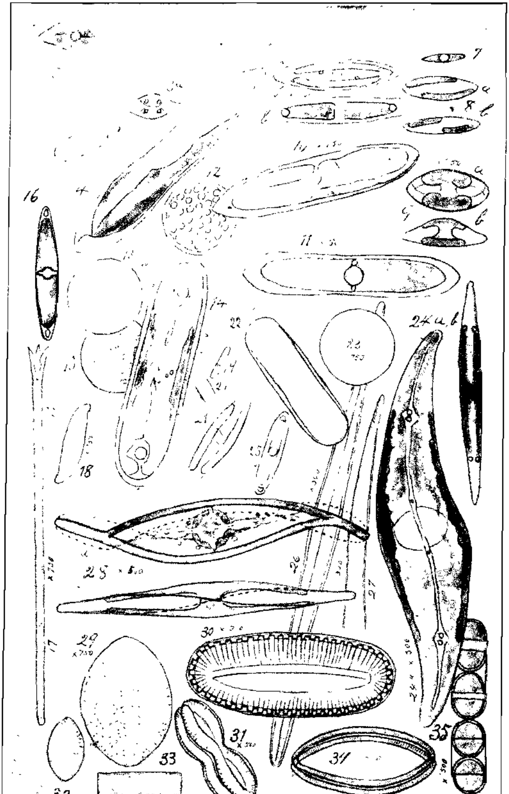

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DESCRIPTION OF FRONTISPIECE.

Most of the diatoms here figured have not been identified, and so only a few will be named. The dark parts in the protoplasmic contents are "chromatophores," usually of a yellowish color; the clear spaces are vacuoles.

Figures 1, 6, 8, 11, 14, 16, 21, 22, 25 are *Navicula*.
Figures 4, 10 are *Amphiprora*; 9, *Cymbella*.
Figures 12, 13, 15, 23 are *Coscinodiscus* species.
Figures 26, 27 are *Nitschias*.
Figures 29, 32 are *Cocconeis* or *Navicula*.
Figure 30, *Surirella*.
Figures 18, 24 are *Pleurosigma*.
Figure 35 is *Melosira nummuloides*.
Figure 33, probably *Diatoma*.

In figures 24 and 28, where two views of the same diatom are given, *a* is the side view, *b* the front view. 24*b* is drawn to smaller scale than 24*a*. In figure 28*a*, the dotted line is the outline of the same frustrule when the bottom edge is raised a little.

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PART I.

EXPERIMENTAL STUDIES IN OYSTER PROPAGATION, 1902.

EARLY DEVELOPMENT OF THE OYSTER EMBRYO.

Sec. 1. Introductory.

The reader of this report who is unfamiliar with the problems involved in oyster culture may, by a few introductory sentences, be enabled to comprehend the particular objects of these researches, for which the State of New Jersey, in 1901, authorized the annual expenditure of the sum of $200. The appropriation therefor has been successively granted by legislative enactment for the seasons of 1901 and 1902.

Oysters, like all living productions, are originated through the *natural reproductive processes, and occur in the state of nature on* reefs, along certain parts of the seashores, known as "natural oyster beds." Each oyster is at first a very minute egg, of which the parent oyster "spawns out"—*i. e.*, ejects—millions every summer. These eggs rapidly develop into small, free-swimming oyster fry, that in a few days are provided with a bivalved shell; and then they settle down on a clean surface, of a shell or stone, etc., to which they become attached by the left side.

The oyster secures its food by means of "ciliary action"—*i. e.*, the surface of the oyster's gills are covered with very small *cilia*, that are shaped like hairs, and which twirl around in the water and draw a current through the pores of the gills. The very small organisms contained in the water become entangled in a layer of slime which covers the gills; this slime is dragged towards the mouth and into

the stomach, also by ciliary action. Thus feeding, the little oyster grows, in the course of three to five years, to a marketable size.

But, on a natural bed, the oysters are crowded together and become misshapen, and, owing to competition, are poor and ill-flavored. Therefore, the oystermen secure these oysters, knocking the clusters apart and then transplant the individuals (called "seed" oysters) to areas called "oyster lots" or "oyster farms," where each oyster is given plenty of room and opportunity to grow faster and so to attain a better flavor than was possible on the natural bed.

It came to pass that the demand for "seed oysters" was so great that the amount securable from the natural beds has been inadequate to the needs of the oyster planters. Therefore, some of these planters have placed shells on their farms, together with a few spawning oysters, and so started an artificial oyster bed, raising seed of their own. Such beds are at first claimed to be natural beds by those who take seed oysters, and are regarded by them as free to all; they take such seed (belonging to the planters by right of the labor expended) and actually sell to the planters their own property. Gradually, however, through laws enacted and new police regulations, property rights in such private beds become more secure.

One reason why natural beds fail to furnish sufficient seed oysters is because, after many seasons' persistent tonging, the shells which the young oysters need for attachment are carried off with the seed. As natural beds are regarded as public property, no private efforts are made to plant shells on such beds to keep up its productiveness. So the State of New Jersey annually expends thousands of dollars planting shells on some of its natural oyster beds, that the planters may have oyster seed. But even with such aid there is a scarcity of seed. Planters find that there are many areas where oysters may be grown and fattened for market where they nevertheless fail to secure seed by planting shells. In fact, the areas where (with our present knowledge) we can secure seed oysters by planting shells are quite limited. Those areas that were once natural beds, but have become depleted so as no longer to be profitable to work, except in a *very small way, can be readily restored to great productiveness by* "shelling." Were all such areas "shelled" at State expense there would be seed enough, but at a very great public cost; and it seems just to believe that it were better for private enterprise to develop such areas. Yet, when private enterprise does restore such areas, they

are still generally regarded as "natural ground," in which there can be no "private property rights." Hence, owing to lack of proper protection, many areas that would yield seed oysters lie idle, while the planter meets with but indifferent success or even failure in shelling the ground which he owns. Even on the best natural beds there is great fluctuation in the amount of oyster "spat" that "sets" from season to season.

Now, nobody is able to tell what causes such fluctuation, and so nobody can tell whether or not the oyster-seed production could be made a sure thing. It is therefore eminently desirable to *study the nature of oyster propagation, to learn the laws that govern oyster development. This is the first great object of our researches.*

Then there is the method of "claire culture," so successful in Europe. A *claire* is a pond along the shore, usually artificially constructed, which is carefully tended and whose water-supply is under perfect control. The immense acreage of salt marsh along our borders, when properly ditched, offers an alluring prospect for oyster culture, did we but know just how to provide for the necessities of the young oysters. This problem calls for the discovery of the same secrets as does the general question above stated; hence the *development of claire culture for the American oyster is the second great object of our researches.*

As these ponds would be under absolute control and private ownership, it becomes, ultimately, our *third object to ascertain how to raise oyster seed in such claires,* so oyster-seed production would be a private enterprise, like the production of vegetable seeds on land.

All these questions depend for their solution on a knowledge of the laws of oyster development—*i. e.,* on what is called, in biology, by the term "ecology." *Oyster ecology is our study,* and our experiments are directed to that end and are not primarily such experiments as a practical oysterman would make. We do, indeed, have such practical experiments ultimately in mind. They are the application of the knowledge gained by scientific study, and, in fact, the two kinds of researches are interwoven. But at this early stage of the study the more practical side is kept secondary.

We make this explanation because, previously, experimenters in America have actually succeeded in raising seed oysters in claires and have announced that they have shown that seed can be raised in this way; so it only remains for the oystermen to go ahead. Unfortunately, oyster seed can be raised in such claires at one time and at

another time cannot; and so we are still forced back to the original question—"what are the ecological laws of oyster development?"

We know very well that we cannot expect to raise oysters in glass tumblers, under the conditions obtaining in our experiments. These experiments were made for the sake of ascertaining why, at one time, our oyster eggs developed shells, and not at all times, under, apparently, the same "unfavorable" conditions; for, undoubtedly, a crowd of millions of oyster fry in a tumbler of sea water must be considered as under extremely unfavorable conditions. Yet, under such conditions, we occasionally secured a complete development of the fry up to the "spat" stage.

Evidently, it is needful artifically and with certainty to secure an unlimited amount of fry in the shell stage before we can proceed to study the conditions of spat fixation. Yet just here we have experienced some puzzling and apparently contradictory results, which we discuss in a later part of this report.

During the season of 1901 only one of our batches of oyster fry reached the full "shell stage," while during the season of 1902 this *stage was reached at least three or four times at different parts of the* summer.

These advanced fry were planted, with cultch, in a tank in which, during the previous season (when we had poorer lots of fry), a few oysters had started and attained some growth; yet not a single "set" was secured in this tank during the past season. It is evident that this result is not to be called a "failure" from an experimental standpoint, because, from such a result, we may make the positive assertion that, whatever the reason for such a "failure" may be, it is not due to any lack of constitution in the fry. We must therefore seek for the answer next season in some other direction. In 1901 this answer could not have been given, for it looked, at the close of our work that summer, as if the failure to raise young oysters under the conditions obtaining in the tank was primarily due to lack of constitution in the oyster fry.

In our report for 1901 we paid especial attention to the developmental phenomena involved in the fertilization and early development of the egg. Taking up the history from this point during 1902, we have accordingly studied the next period of development, viz., the early development of the oyster embryo. The data secured under this head are exhibited on Plates I., II. and III.

These phases of the history, being more complex than those presented in the fertilization of the egg, and also less familiar to the investigator, have not been so satisfactorily nor so completely worked out as were the earlier phases: much therefore remains for future studies to complete. The thoroughness of these studies was also interfered with by various incidental investigations, and particularly by a desire to ascertain whether the various varieties of oysters differed in their developmental viability.

We had found, at the close of the previous season's work, that only one lot of fertilized eggs developed as far as the shell stage. We wished, therefore, to ascertain if possible why the other experimental lots failed to complete their early development. It seemed to us that there were three possible causes for this failure: (1) the proper variety of oysters was not used; (2) the eggs were not properly handled; (3) the eggs were not in a proper stage of maturity.

Each of these three causes was tested experimentally during the season just past, and while the data secured do not enable us to give a fully satisfactory answer to these questions, yet real progress has been made in that a partial answer has been secured.

First of all we found that native seed is not superior in developmental vitality to oyster seed imported from distant localities. Contrary to expectation, southern plants were found to equal or possibly to exceed native seed in developmental constitution. We found that *the successful viability is not confined to any one variety of seed.*

Next, we found that the most careful handling of the eggs did not seem to secure the desired viability in the great majority of the experiments. In those experiments that showed the desired viability no especial care was taken.

Thirdly, we worked with eggs of the very choicest appearance, and as mature as possible, using both those that were just about to be spawned out and those that remained after the oyster had begun spawning.

Apparently, as a result of carefnl selection in this regard, we obtained a higher percentage of viability during the season just past than during any previous season. This result is in harmony with our fundamental dictum, viz., that the success of oyster development depends on the inherent vitality of the eggs. Nevertheless, there are some puzzling features connected with the results of our experiments, and it seems as if it would be necessary to make a careful study of

natural spawning on natural beds, to clear up these matters. We do not know that when an oyster spawns naturally, all its eggs are able to develop into "sets" in even the most favorable situation. Perhaps the eggs of a proportion of the spawners may not have sufficient viability. Why is there so great a variation in the number of sets produced on the natural beds from year to year?

Captain Joseph K. Ridgway, of Barnegat, President of the State Oyster and Shell Commission, writes me, October 14th, 1902, as follows:

"There was but a light set of spat on the Cedar Creek beds in 1901, * * * there was very little set on shells in any part of Barnegat bay this summer. Prices are at least twenty-five per cent. higher than *last year, and 'plants' are hard to get.* * * * *It sometimes happens* that a fair set will adhere to shells on one part of an oyster lot and none on other parts. Why this is so we cannot tell. We wish we could."

George A. Mott, of Tuckerton, Secretary of the Commission, wrote me, October 24th, 1902, to wit, "The catch this year is very light and late. We had a fine lot of plants gathered from the beds at the mouth of Mullica river."

Watson T. Sooy, of Green Bank, wrote, October 20th, as follows: "There was a light (late) catch on all shells in the Mullica river. The first I examined were about the 20th of September."

We may make guesses at the cause of this partial failure of nature to provide a set on the shells placed in proper position by man. We may say there was a lack of spawning oysters, or the eggs were not properly matured, or the shells were not planted at the right time, or the summer was too dry and cool, or that the water was too salt or too fresh, etc., etc., but no one *knows* anything for certain about it, simply because the matter has never been the subject of continuous, scientific inquiry.

Yet this problem *must* be solved before we can develop a good system of artificial oyster propagation. It is to answer such a question as this that this work was undertaken. It is clear that it is a matter requiring time and patience and even additional experimental workers.

It is hoped that the small appropriation authorized by the State will be continued to be appropriated as long as the experiments are thought worthy of continuance. Certainly the matter should be thoroughly investigated and not abandoned so long as there is hope of

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The work of the season of 1902 began a week earlier and continued a week later than during the previous season. This was due to the fact that for some reason the oysters matured earlier than usual and remained in a spawny condition longer than usual. The first oysters were opened June 12th and were found to have completed spawning. The last spawn was taken September 3d. Not all the time intervening between these dates was spent at the Station. In all, the investigator passed an average of four days per week for ten weeks at Mott Station, engaged in various experiments and studies, bearing on the problems stated in our introduction. The results are exhibited in the text and plates of this report. These results may be classified under the following heads: (1) Development of the oyster embryo; (2) Oyster food; (3) Comparative viability of different kinds of oysters; (4) Oyster parasites; (5) Enemies of the oyster fry, and other incidental experiments. In fact, the work was really too varied for much progress to be made in any one direction. Yet such varied general surveys are necessary to aid in planning future work.

Visits were made to Barnegat for the first two weeks, but the conditions here being quite unfavorable for the experiments, we thenceforth confined our attention to Mott Station, at the mouth of Stopwater Creek, on the Great Bay meadows, four miles south of Tuckerton, at which place we secured as fine specimens of "spawny" oysters as we ever saw for the longest period in our experience.

The successive lots of oysters opened are indicated by the Roman numerals; the kind of oysters, their condition and history, the number of ripe males and ripe females secured, the hours and dates when they were opened, are indicated in the first of the following tables.

The next table indicates by Arabic numerals the successive lots of spawn fertilized and started on the developmental path; the oyster lots from which the spawn was secured and the date and hour of starting the experiments.

The third table shows the temperature at different times of the day, on important days of the investigation. The data were not secured for the first two weeks, owing to lack of thermometer, later secured.

Next follows a description of the experiments and their results.

Table of Oysters Used in Experiments.

ABBREVIATIONS: N.—Natives; B.—Bays; Cr.—Creek; E. R.—East River; H. I.—Hog Island Virginias; Gr.—Great; El.—Elder; Barn.—Barnegat; Tuck.—Tuckerton; Opnd.—Opened; Spnd.—Spawned.

DATE.	Hour opened.	Lot.	Designation.	Condition and history.	Ripe males.	Females.	Condition of eggs.
June 12	1:30 P. M.	I	N. Barn. B.	Half spnd.	...	...	
" 12	1:30 P. M.	II	N. " Cr.	About "	...	...	
" 13	9:30 A. M.	III	E. R. Barn.	Nearly "	...	...	
" 13	5:00 P. M.	IV	E. R. Tuck.	About "	...	...	
" 13	5:00 P. M.	V	N. "	Good.	...	...	
" 13	5:00 P. M.	VI	H. I. "	Very good.	...	...	
" 17	12:00 NOON	VII	N. Barn. Cr.	Freshened on Float	1	1	Opake, Vesicular.
" 17	12:00 NOON	VIII	N. " B.	" " "	0	0	
" 17	2:00 P. M.	IX	N. " Cr.	From bottom, 22 discarded	1	1	Not ripe.
" 18	3:30 P. M.	X	H. I. pond.	Very good.	8	4	Irregular.
" 18	3:30 P. M.	XI	H. I. Gr B.	Good	1	8	Granules outside eggs.
" 18	3:30 P. M.	XII	N. El. Cr.	Fair.	2	6	
" 24	4:00 P. M.	XIII	Mixed Cr.	"	3	4	
" 24	4:00 P. M.	XIV	N. El. Cr.	Only one "good."	1	6	
" 24	4:00 P. M.	XV	H. I. Gr. B.	Good.	2	8	
" 24	4:30 P. M.	XVI	H. I. pond.	"	4	9	Granular.
" 25	10:30 A. M.	XVII	N. Mullica.		...	...	
" 26	12:00 NOON	XVIII	N. El. Cr. (float).	Good.	...	...	
July 7	12:00 NOON	XIX		Mott's experiment.	...	...	
" 9	10:30 A. M.	XX	Mixed Cr.	Part spnd.	4	9	
" 9	5:00 P. M.	XXI	Clams.	Immature.	9	5	
" 9	7:00 P. M.	XXII	Cr. bank.	Good, put naked into sea water.	1	1	Part decomposed.

Table of Oysters Used in Experiments.—Continued.

ABBREVIATIONS: N.—Natives; B.—Bays; Cr.—Creek; E. R.—East River; H. I.—Hog Island Virginias; Gr.—Great; El.—Elder; Barn.—Barnegat; Tuck.—Tuckerton; Opnd.—Opened; Spnd.—Spawned.

DATE.	Hour opened.	Lot.	Designation.	Condition and history.	Ripe males.	Females.	Condition of eggs.
July 15	3:00 P. M.	XXIII	E. R. Cr.	All spnd.	.....	.....	
" 16	4:00 P. M.	XXIV	Cr. bank.	Fine, put naked into tank	7	9	
" 16	12:00 NOON	XXV	" "	" " " " "	1	5	
" 17	4:00 P. M.	XXVI	" " (?)		.....	.....	
" 18	7:00 A. M.	XXVII	" " mixed El. Cr. N.	Fine, put naked into tank	2	2	
" 18	12:00 NOON.	XXVIII	H. I. pond	" " " " "	3	3	
" 22	4:00 P. M.	XXIX	Cr. bank, H. I. pond	3 discarded	2	2	
" 22	4:00 P. M.	XXX	Cr. bank, N. pond	Best, 4 discarded	1	3	
" 29	5:30 P. M.	XXXI	" " " "	Good	1	1	Granular.
" 29	5:30 P. M.	XXXII	Cr. bank, H. I. pond	Very good	2	4	
Aug. 5	12:00 NOON	XXXIII	Cr. bank	All spnd	.....	.....	
" 5	12:00 NOON.	XXXIV	H. I. pond	Good	3	5	
" 26	5:00 P. M.	XXXV	N. pond	"	5	3	
" 26	5:00 P. M.	XXXVI	H. I. pond	"	1	1	
Sept. 2	8:00 A. M.	XXXVII	Cr. basket	About spnd	2	1	Poor.
" 2	6:00 P. M.	XXXVIII	H. I. pond	Spawned out	.....	.....	
" 2	6:00 P. M.	XXXIX	S. pond	Nearly spnd. out	3	1	
" 3	9:30 A. M.	XL	N. pond	" "	2	1	

Table of Fertilization Experiments.

DATE.	Number.	Hour.	Oysters used.
June 12...	1	2:00 P. M.	I., II.
" 13...	2	10:00 A. M.	III.
" 13...	3	5:00 P. M.	IV., V., VI.
" 17...	4	12:30 P. M.	VII.
" 17...	5	2:30 P. M.	IX.
" 18...	6	4:00 P. M.	X., XI., XII.
" 18...	7	5:45 P. M.	X., XI., XII.
" 24...	8	4:15 P. M.	XIII., XIV., XV., XVI.
" 25...	9	11:00 A. M.	XVII.
" 26...	10	12:30 P. M.	XVIII.
July 7...	11	....	XIX.
" 9...	12	11:00 A. M.	XX.
" 9...	13	5:30 P. M.	XXI.
" 10...	14	9:15 A. M.	XXII., soaked.
" 11...	15	6:00 P. M.	XXII., soaked.
" 15...	16	5:00 P. M.	XXIV.
" 16...	17	1:00 P. M.	XXVI., clams.
" 17...	18	3:00 P. M.	XXIV., soaked, XXV.
" 17...	19	4:30 P. M.	XXIV., soaked. XXV., soaked.
" 18...	20	7:15 A. M.	XXVII.
July 18...	21	12:30 P. M.	XXVIII.
" 18...	22	3:45 P. M.	XXIV., soaked.
" 19...	23	10:00 A. M.	XXIV., XXV., XXVII., XXVIII., all soaked.
" 22...	24	4:30 P. M.	XXIX., XXX.
" 29...	25	6:00 P. M.	XXXI., XXXII.
Aug. 5...	26	12:30 P. M.	XXXIV.
" 26...	27	6:00 P. M.	XXXV., XXXVI.
Sept. 2...	28	8:30 A. M.	XXXVII.
" 2...	29	5:30 P. M.	XXXVIII., XXXIX.
" 3...	30	10:00 A. M.	XL.

Air Temperature (Fahr.) at Mott Station.

DATE.	Hour.	Degree.
June 24..	4:30 P. M.	78
" 24..	7:00 P. M.	70
" 25..	7:00 A. M.	65
" 25..	12:00 NOON.	75
" 26..	12:00 NOON.	78
" 27..	5:00 P. M.	82
July 9..	7:00 A. M.	60
" 9..	10:00 A. M.	85
" 9..	12:00 NOON.	85
" 9..	7:00 P. M.	80
" 10..	8:00 A. M.	64
" 10..	10:00 A. M.	68
" 10..	3:30 P. M.	84
" 10..	6:00 P. M.	80
" 11..	6:00 A. M.	60
July 15..	12:00 NOON.	84
" 15..	6:00 P. M.	78
" 16..	9:00 A. M.	76
" 16..	5:00 P. M.	82
" 17..	8:00 A. M.	70
" 17..	3:30 P. M.	90
" 18..	7:00 A. M.	80
" 18..	10:00 A. M.	88
" 18..	4:00 P. M.	82
" 19..	7:00 A. M.	72
July 22..	4:30 P. M.	84
" 23..	7:00 A. M.	68
" 23..	3:30 P. M.	80
" 23..	7:00 P. M.	74
" 24..	7:00 A. M.	74
" 24..	12:00 NOON.	80
" 25..	8:00 A. M.	72
" 25..	12:00 NOON.	70
July 29..	4:00 P. M.	80
" 29..	8:00 P. M.	80
" 30..	7:00 A. M.	78
" 31..	8:00 A. M.	74
" 31..	12:00 NOON.	80
Aug. 1..	7:00 A. M.	72
Aug. 5..	12:00 NOON.	82
" 5..	4:00 P. M.	84
" 6..	6:00 A. M.	76
" 6..	9:00 A. M.	80
" 6..	12:00 NOON.	82
" 7..	10:00 A. M.	76
Aug. 26..	6:00 P. M.	77
" 27..	6:00 A. M.	67
" 27..	9:00 A. M.	77
" 27..	11:00 A. M.	80
" 27..	12:00 NOON.	82
Aug. 29..	6:00 A. M.	67
Sept. 2..	7:00 A. M.	80
" 2..	12:00 NOON.	82
" 2..	7:00 P. M.	82
" 2..	10:00 P. M.	80
" 3..	7:00 A. M.	70
" 2..	12:00 NOON.	80
" 2..	7:00 P. M.	77
" 4..	7:00 A. M.	75
" 4..	12:00 NOON.	77
" 4..	7:00 P. M.	70

Description of the Experiments.

June 12th, Thursday.—In houseboat of Captain J. K. Ridgway, at Barnegat. Opened (lots I., II.) native oysters from creek and from bay; both nearly through spawning; the former most advanced. Also, the plants from East river (III.) were about through spawning.

Experiment 1. Spawn lots *a* and *b* prepared from I. and II.

Experiment 2 was prepared next morning from III.

June 13th, Friday afternoon.—At Mott Station. East River plants (IV.) nearly spawned out; natives (V.) in fair spawning condition; Hog Island (southern) plants (VI.) best of all.

Experiment 3. Spawn lots *a*, *b* and *c* were prepared from IV., V. and VI., and left in dishes on table.

An incursion of drumfish had invaded the planted oyster-beds at Tuckerton, crushing the oysters in their capacious jaws with their powerful throat grinders and threatening the total destruction of the crop. Finally, the planters exploded dynamite in the water, with apparent success, killing great numbers of the fish and probably succeeded in frightening the rest away, but not until after a large proportion of the planters had lost their entire stock.

June 17th, Tuesday.—At Barnegat; found spawn lots 1 and 2 of previous Thursday decomposed. Recent heavy rains had made the water of the creek nearly fresh. This water was still quite fresh the following Friday, containing only half a per cent. of salt.

The native creek plants (VII.) and from bay (VIII.) had been left on a float, where they had felt the greatest influence of the fresh water. The eggs were decomposing in the oysters and were entirely unfit for use in VIII. So selected some creek natives that had not been removed from the bottom, but out of one dozen opened we found only one ripe male and one nearly ripe female.

Experiments 4 and *5* were prepared from VII. and IX., but no development followed. This was due either to the effect of the fresh water on the oysters or on the spawn, probably both causes acting successively.

June 18th, Wednesday.—At Mott Station lively embryos were found in spawn lots 3, *a*, *b*, *c*, but, also, there was an extensive development of infusors. One embryo was seen in lot 3*c* (Hog Island plants) that had reached the shell stage. This statement does not mean that only *one* such embryo was present, but that, on account of the smallness

of the fry, a high magnification was necessary to examine them, and this involves a correspondingly restricted field, so that hundreds of other embryos in the shell stage may have been present, but escaped observation by not being included in the few drops of water taken for examination.

Opened lot X., Hog Island plants, from the pond; found three ripe males and four spawny females; two of these were opened an hour or two before the others. From these seven, prepared spawn lot *6a*.

Lot XI. consisted of Hog Island plants, from the pond; one male and three females. Spawn lot *6b* prepared from these, and sperms from lot X. also added.

Lot XII., Elder Creek naturals (with least spawn); two males and six females chosen; also added sperms from X. and XI., to make spawn lot *6c*.

Experiment 6. Prepared from X., XI. and XII., then divided the lot into six portions.

Experiment 7. From same oysters as 6, making separate fertilization of each female, with mixed sperms of all the males.

Next morning, Thursday, June 19th.—All lots of 6 and 7 show good swimming embryos except 7, XII.*c*, but those from XI. and XII. were weaker than in X. The embryos were carefully separated from *debris*. They seem to be attracted to the illuminated side of the tumblers, ascending to the surface and descending in columns, as shown on Plate IV.

Cleaned tank. Weather showery and becoming warmer.

June 20th, Friday morning.—All the lots of *Experiment 6*, now thirty-eight hours old, were in shell stage and swimming on the bottom. They were planted in the tank with cultch of various sorts —wood, stones, shells. Tuesday, June 24th, these were examined, but showed no signs of a "set."

June 24th, Tuesday.—*Experiment 8.* From XIII. to XVI., inclusive. Comparison of four sorts of oysters. Pond (Hog Island) still keep up their reputation as superior, yet none of this lot reached the shell stage.

June 25th, Wednesday.—Mr. W. T. Sooy brought natives from Mullica river (lot XVII., *Experiment 9*).

Studied rotation of the swimming fry of *Experiment 8*, sixteen hours old. Calling the broad end of the embryo the front, where the polar globule is situated, and where a special circle of long cilia is first developed, and the hollow side the belly, as seen in the microscope, the

embryo swims forward and at the same time turns a somersault by throwing the head down and posterior end up; also, at the same time seen from behind, it turns on the longitudinal axis in same direction as the hands of a watch. In a "life-box" the fry soon use up all the air, and then those next an air bubble rotate on the longitudinal axis only, having the front against the bubble. Those at a distance from such bubble turn on the horizontal axis only, or spin round in a circle. *When first placed in the life-box the normal spiral course is maintained.*

Some of these embryos were planted in the tank from day to day. None reached the shell stage by Friday, June 27th, when they were seventy-five hours old.

June 26th, Thursday.—Windy, heavy rain fell last night. Fertilixed good naturals from Elder creek that had been on float in Stopwater creek, and secured a good development (*Experiment 10*). These were planted in tank when four and a half hours old.

June 27th.—Investigated improved ditching machine at work on marsh owned by the Sooys, at Chestnut Point, on the Mullica, below the bridge from New Gretna. Filtered water from tank and found embryos in same stage as those lately planted.

July 8th, Tuesday.—Found the best embryos in the flat dishes of lot XIX., fertilized by Mr. Mott yesterday. This lot gradually died out without giving further results of value.

July 9th, Wednesday.—Prepared *Experiment 12* from creek oysters (XX.). These had partly spawned out; the eggs in such individuals appear partly decomposed. It seems as though only the eggs spawned out first are good, and probably, in a state of nature, very few oysters succeed in completely emptying their generative ducts. The eggs remaining are absorbed. Specific gravity of the creek water was 1,017. This was maintained nearly steadily throughout the season; it is also a degree of saltness quite suitable for oyster culture.

Fry of *Experiment 12* was kept in dishes floated in the tank, because of the high air temperature, but it became much cooler at end of the week. This lot became invaded by infusors and the fry decomposed, but not until they had begun to show the rudiments of the shell at forty-three hours.

Experiment 13. Fertilized the eggs of five female clams by sperms from nine male clams. Clam eggs have a thick, jelly-like coating outside a thin, firm shell that rests on the yolk. No special micropyle

was visible. The sperms penetrated the outer coat readily at any point. An empty shell was soon covered by sperms. This experiment resulted in a lot of lively embryos in three and a half hours, but the next morning, thirteen hours later, they had all died.

July 10th, Thursday.—Opening oysters for supper, we found two exceptionally spawny oysters (XXII.), that proved to be one of each sex, the genital ducts showing nicely in the male. Though they had been opened, they were placed in sea water over night and subsequently trasnferred to a small float in the tank, where they were kept several days. The spawn was carefully pressed from the ducts by the natural openings and not cut off, as in our previous practice. Thus we kept the same specimen, taking spawn from day to day, but even at the first taking of spawn the eggs had decomposed in part. Four subsequent lots of oysters opened were treated in a similar manner, soaking "naked" in sea water.

Experiment 14 was prepared from XXII., that had soaked all night in sea water. The dishes were floated in the tank to keep from becoming excessively hot; the water in the tank rarely rising above 82° F. In a few hours we had a fine-looking lot of embryos, but by next day evening, when only thirty-one honrs old, they were abont all dead, as were those in lot 12.

July 11th, Friday.—Saw dredge work at Chestnut Point. The water in the Mullica was practically fresh. The shells in the cove bore dead "sets" of last season, but none of the present season.

Experiment 15. Prepared from the oysters (XXII.) soaked forty-eight hours. Floated the dishes over night and found nice-looking embryos next morning, July 12th. These were planted in the tank, but came to nothing.

This experiment shows that rather rough handling of oysters will not prevent early development from occurring, although even a slight amount of unnatural treatment of oysters will prevent the eggs from developing in the later stages.

July 15th, Tuesday.—Following a very hot day. Oysters (XXIV.) left on the bank at the creek and exposed to the sun at low tide; proved full of spawn, whereas eastern seed, snbmerged, was entirely spawned out.

Experiment 16. Prepared from XXIV. Part planted at fourteen hours; mostly dead at thirty-nine honrs. A few live eighty-six hours, but not yet in shell stage.

Experiment 17. Fertilization of clams; no success. Temperature of water in creek 76°; in tank, 72°.

July 16th.—Studied contents of the gray ooze which covers the black mud. The gray coating consists of living organisms, largely diatoms, the main food of the oyster. The deeper and darker mud contains the skeletons of diatoms, grains of sand, carbonized relics of cellulose walls, dead and living bacteria, etc.

Oysters XXIV. were left attached to their right valves, covered by the left valves and placed in the tank. This treatment so disturbed their functions that, whereas the ciliary action had accumulated lots of food-laden slime, this had failed to reach the mouth, but was heaped up in various places on the body.

The water in the tank was 76° F., two degrees cooler than outside, in the creek, and four degrees cooler than the air.

July 17th.—*Experiment 18.* Prepared from XXIV., soaked nearly two days, and XXV., soaked nearly one day, naked, in sea water, to determine whether eggs and sperms, after such soaking, unite at once, or still retain the latent period of ten minutes (found last year in fresh spawn), but the experiment did not prove very satisfactory or conclusive. An earlier experiment with spawn from fresh oysters seemed to show that when the spawn is expressed and then soaked ten minutes, the latent period disappears.

Experiment 19. Fertilized spawn lot from XXIV. gives a fine lot of fry next day at fifteen hours, but at thirty-nine hours it was destroyed by infusorial development.

July 18th, Friday.—*Experiment 20.* Oysters XXVII., natives and mixed from Elder creek, that had lain on the bank of Stopwater creek, on being opened, presented some splendid-looking specimens of spawny oysters. The spawn prepared from them scarcely developed.

Experiment 21. From pond, Hog Island (XXVII.), freshly brought in, showed a fair development at twenty hours. Planted in tank, but failed to become spat.

Experiment 22. From XXIV., soaked seventy hours; after sixteen hours shows many infusors and a few fry.

Lots XXVII. and XXVIII. were put naked into the tank. In the old lots (XXIV., XXV.) the heart had ceased to beat.

Studied mode in which Gammarus, a water flea, captures oyster spawn.

July 19th.—*Experiment 23.* Only two oysters in the four lots soak-

ing in the tank have their hearts still beating. Spawn was taken from the others and fertilized and planted at once.

July 22d, Tuesday.—Oyster lot XXIX.; same as XXVIII., but had been left since the 18th on the banks of the creek, where they were covered only at high tides.

Experiment 24. Used Hog Islands (XXIX.) and natives (XXX.) *from pond left on creek bank since last week; the latter appeared* better than the former, but the former came out ahead in the development, though this became abortive, in both cases, before the close of the week; the temperature had been kept fairly level by floating the dishes in the tank. This lot of embryos showed a peculiar flagellum, just back of the position of the future mouth, not noticed in other lots. See Figures 14, 15, Plate II. The beginning of a shell was noticed after forty-four hours, but the velar disk was very peculiar in being covered by a transparent, shell-like layer and lacking cilia. None survived beyond the end of the week.

July 29th, Tuesday.—*Experiment 25.* From XXXI. and XXXII., involving one native female and four Hog Island females; one native male and two Hog Island males fertilized as follows:

a. N. female by N. male.
b. N. female by H. I. males.
c. H. I. females by N. male.
d. H. I. females by H. I. males.
e. Separate females by mixed males.

The second Hog Island female was the only one with fine eggs; *a* was better than *d,* and *c* than *b,* thus showing advantages of crossing. Most of these fry reached the shell stage at sixty hours and survived to eighty-three hours. The formation of the shell was delayed, though the temperature ran uniformly, nearly 80°. Hence the lot must be considered somewhat abnormal.

Some of the lots, at forty-two hours, showed the embryos fusing together by twos and threes. The development of infusors was rapid, too. Studied ciliary movement.

On August 1st, Friday, at sixty-eight hours, the spawn was thus:

a. Infusoriated, a few reach shell stage.
b. Very few left, and only early shell stage reached.
c. and *d,* many lively, but abnormal.

On August 2d, Saturday, at eighty-three hours, the Hog Island female, by native male, best of the four lots, but shell stage not properly developed. A few in shell stage in native female by Hog Island female, but not fairly successful.

August 5th, Tuesday.—Found that the oysters on the creek bank so very "spawny" last week had emptied themselves.

Experiment 26. From oysters XXXIV., females as follows:

a. Pond native, eggs granular, little spawn.
b. H. I. from pond, eggs better, more spawn.
c. H. I. from pond, eggs coarsely granular, still more spawn.
d. H. I. from pond, eggs irregular and slightly granular, most spawn.
e. H. I. from pond, eggs nearly like *d.*
f. H. I. from pond, eggs nearly like *a.*

In four hours the embryos were rising, making a fine show in *e, a* and especially *b;* poor in others. Added rainwater at night to counterbalance evaporation. At forty-six hours no sign of a shell, except in few *accidentally introduced into the tumblers containing diatoms,* for study. Fry survived until end of week, when they were planted.

August 26th, Tuesday.—*Experiment 27.* With XXXV. and XXXVI., as follows:

a. N. females by mixed sperms.
b. N. female by H. I. male, poor results.
c. N. female by N. male, good result.
d. H I. female by mixed sperms.
e. N. female by H. I. male.
f. H. I. female by N. sperms, best results.

Good development: embryos streaming at fourteen hours; planted half of fry. Rest failed to reach shell stage and were decomposed by end of week.

September 2d. — Pond natives in basket on creek bank about spawned out. New lot of oysters from pond also well advanced, but secured some spawn for *Experiments 28* and *29* and repeated next morning. These lots were prepared for staining. Tried borax carmine, picrolithium carmine and Böhmer's Hæmatoxylin; the last gave the best results.

Spent rest of week in arranging a new kind of filter gate, to be tried the season of 1903.

Sec. 3. Discussion of Special Features and of the Illustrations on Plates I. to VI. and Frontispiece.

THE EARLY DEVELOPMENT OF THE OYSTER EMBRYO. PLATES I. TO III.

The figures were drawn, in nearly all cases, from the living specimens, by the aid of a camera lucida. These sketches were enlarged by pantagraph and have been again reduced by the electrotyper. With two or three exceptions, the figures represent the unmodified original drawings. The exceptions were made up from features in two or three separate studies. I found it unexpectedly difficult to interpret the images shown in the microscope; large special yolk grains make more show than some transparent, yet significant structures. The most difficulty encountered concerned the normality of the development.

Again and again did we keep oyster embryos for more than three days, in which the shell stage failed of development, but the embryos underwent successive changes, that were of teratological nature, or were features of degradation.

So far as our experience went, under temperatures that hovered near 80° F., we may, I think, safely conclude *that if a lot of spawn fails to reach the shell stage by the close of the second day, it will prove to be an abnormal development.*

This is an important conclusion and is a completely revolutionary revelation to our ideas hitherto held. It follows that many of the views shown of embryos are more or less departures from the normal. Here is a splendid field for the study of experimental teratology.

Of course it becomes necessary to ascertain exactly what a normal development is, if we are to make any good progress in the study of the ecology of oyster development.

The figures on Plate I. follow exactly in serial order the last figures of the last plate (VIII.) of our last previous report (1901).

Figure 1 shows the embryo at four hours in optical section, front to back view. At the lower pole are situated two large, yolk-laden cells (macromeres) that are surrounded or capped by a layer of small cells (micromeres). A narrow space (*s.c.*) separates the two sorts of cells. This is the segmentation cavity. The small cells are known as "ectoderm;" the large inner ones are "endoderm."

Figure 2 shows the same embryo, viewed from below. The part of the endoderm left uncovered by the ectoderm is the position where will appear the gastrula mouth (or blastopore).

Figure 3 shows the top view of the same embryo in the beginning of the gastrula stage, at five hours, seen in optical section from above or below. The macromeres have split up into quite a number of endoderm cells.

Figure 4 shows an optical section of the gastrula, viewed from in front. The posterior portion of the embryo is shown in projection shaded. Just in front of this, on the lower part of the figure, it will be noticed that the surface bends up into the mass of endoderm cells, forming a sort of recess, pit or bay. This hollow is the beginning of the gastrula cavity, which will eventually become transformed into the stomach.

Figure 5.—Side view of an embryo in the same stage as Figure 4. The polar globules (*p.g.*) are seen in place; the position of the gastrula invagination is indicated; the broad end (vertically measured) is the future front end of the oyster and faces to the left; the posterior end is actually wider (though narrower vertically) than the front end. The gastrula at this stage is somewhat depressed as a whole.

Figure 6.—The gastrula stage completed at ten hours. The ectoderm, the endoderm and the gastrula cavity, or stomach, are completed. The gastrula mouth (*b*) is now open. It soon closes up.

Figure 7.—Side view of a slightly older embryo at the time it begins to swim, about twelve hours after fertilization. At the front end a circle of cilia has formed, surrounding the polar globules, which, by the superior development in the upper part, just behind, have been pushed more to the front. These cilia become quite long, and by their movement the embryo spins round in the direction indicated by the arrows. The cilia, of course, strike the water most forcibly in the opposite direction. The arrow in front of the figure indicates rotation of the embryo about a transverse axis (one perpendicular to the plane of the page). The other arrow indicates rotation about the longitudinal axis. Soon the entire body becomes covered by a development of shorter and smaller cilia. The gastrula mouth has closed at *s*, where the shell will first appear, while at *m*, on the apparent back of the embryo, is a depression marking the position of the future mouth. Hence, what we have hitherto represented as the back of the embryo is henceforth to be known as the belly, and the subsequent figures are placed with the mouth (or ventral side) lowermost. If Figure 7 be rotated so as to bring *m* on the lower side, the anterior circle of cilia will point to the right, as in Figure 11. In Figure 8 this circle is shown on the left end, but that is because we are

viewing the embryo from the side opposite to that shown in 7. As seen in the microscope, 7 is viewed from the right side, 8 from the left side, and, in general, all the figures with these long cilia (known as velar cilia) on the left end of the figure are left side views; those with the velum pointing to the right (when the belly is downward) are right side views. But it must be remembered that the apparent right side, seen in a compound microscope, is really the left side, because the lenses in this instrument invert the images of objects. To avoid confusion, we treat these images as real and ignore the fact of the inversion.

Figure 8.—Embryo at twenty-three hours, viewed from the left side. The segmentation cavity, which is a sort of body cavity, is shown; *also the stomach (st), the beginning of the intestine (?), at i*, and of the "liver," which is a bud from the stomach, at *l*.

Figure 9.—From the right side, a specimen at sixty-eight hours, in a greatly retarded condition of development and partly abnormal. It shows the "shell gland" at *sg*.

Figure 10.—From the left side, at thirty-seven hours. At *m* is apparently forming a mouth, leading by a gullet to the stomach.

Figures 11 and 12 show the presence of special patches of long cilia at *c*.

Plate II.—Figures 13 and 14 are embryos at twenty-three and forty hours, respectively. The latter is belated and probably abnormal. The velar disk (*v*) is covered by a shell-like membrane and lacks cilia; at *f* is a peculiar flagellum (also shown in Figure 16) in place of a mouth.*

Figure 15 is a view of an abnormal embryo from below, somewhat obliquely, to show the graduation of the long velar cilia into the medium-length ventral cilia. This embryo lacked cilia elsewhere.

Figure 17 is a view of an embryo from above, at about forty hours, somewhat abnormal. The shell gland lies transversly across the back.

Figure 18.—At thirty-seven hours; shows the disappearance of cilia in the dorsal region, where the shell will form.

Figures 19 and 20 show the beginning of the shell at *sh*, at the beginning of the second day of development.

Plate III.—Figure 21. An embryo, from the right, at forty hours, showing the marked development of the shell valves, the protruding

*** It is just possible that this flagellum represents fused velar cilia, and the velar disk is the shell area, but the position of the shell gland seems to militate against such a view.**

velum and the peculiar swelling on the posterior half of the dorsal part of the right valve (same on left, not visible, because hidden).

Figure 22.—View of embryo at forty hours, obliquely from above, to show at *h* the hinge area; very short at the early stage.

Figure 23.—View of embryo at forty hours, directly from above.

Figure 24.—Same embryo as in Figure 23, from right side.

Figure 25.—Same embryo, from left side, and viewed partly from in front and below; at *m* is shown the mouth, just back of the velum. (The presence of the velum in these larvæ causes them to be known as veligers.) Note the short cilia on the edge of the mantle, not lying against the right valve; also the posterior bulging seen on the left valve; that on the other valve hidden from view.

Figure 26.—View of a slightly more advanced veliger than in Figure 25; the first gills (?), perhaps, are visible at *g*. Note the presence of the polar globules on the velar disk, even at this late stage—forty-eight hours.

Figure 27.—A veliger supposed to be sixty-eight hours old, but degenerating.

Figure 28.—A veliger thirty hours old, viewed from below.

Figure 29.—The same from left side.

ENEMIES OF OYSTER FRY. PLATE IV.

Plate IV. shows, in the first six figures, some of the infusors that develop rapidly in the glasses in hot weather and which feed on the embryos.

Figures 1 and 5 are probably the same species of infusor magnified three hundred times.

Figure 3 is probably a young form of Figure 2; probably *amphileptus;* compare *Litonotus; cv*—contractile vacuole, *n*—nucleus, *m*—mouth.

Figure 4 (*a, b, c*).—Three views of an infusor, not identified.

Figure 6.—A remarkable animalcule, with spiral, ciliated ridges on its body and a beak surrounded by a circle of specially developed, grasping cilia. In *a* the front of the body is shown extended and the cilia twirling. In *b* the head is retracted and the cilia are grasping (only the two side cilia are shown). The entire circle "grasps" at once and at frequent intervals.

Figure 7.—A tumbler of oyster spawn, after the fry becomes free, swimming, but before the shell is developed. Note how the fry rises to the top of the water, through which they are nearly evenly distributed, but that then they at once descend to the very bottom in peculiar columns. The different individuals travel at different speeds, and so there accumulates (at different levels) a mass or knot on the column, which drops or swims faster than the rest of the column.

Figures 8 and 9.—Oyster fry in the shell stage, thirty and forty hours after fertilization, seen from below. Figure 8 shows the anterior adductor muscle (*am*); also the hinge line (*h*), now quite long, shining through the semi-translucent body.

GREGARINOID PARASITES IN OYSTERS. PLATE V.

Plate V.—Figures 1 and 2. These peculiar parasites develop in the reproductive ducts, and quite a proportion of oysters (about one percent.) is thus afflicted. They are but little larger than oyster eggs and about as numerous, so that the oyster looks as if full of spawn. The supposed spawn proves to be Gregarine-like organisms, when viewed microscopically. They develop from spores, one shown at 8. A little later they appear as in 7, then as in 5 and 6. The two arms and "head" develop as shown in 4, 1 and 9. In 9 one of the arms is shown in an extreme length. It becomes detached, as shown in 2 and 3. Figure 10 is an enlarged portion of one of the arms. It is supposed, these arms, when detached, may develop into "nurses." Figure 11 shows a long, much larger nurse, filled with young. Whether this has developed from an arm or by enlargement of a form like 2, 3, we do not know. Forms 2 and 3 are developing peculiar cavities, which may well be brood-chambers for viviparously developing eggs or spores.

Figure 12 (*a* and *b*).—Ventral and dorsal views of a very common infusor in our spawn lots, viz., *Stylonychia* (sp. ?). This infusor has cilia only along the groove leading to the mouth. It has peculiar posterior spines and "crawling" or "running" or "walking," claw-shaped cilia on an elevated disc on the ventral side, along the aforesaid groove.

Figure 13 is probably a *Euplotes,* a near relative of *Stylonychia.*

Figures 14 to 19 are unidentified infusors, common in our oyster experiments. In 16*b* an individual is shown dividing into two new

beings, the common method of reproduction among unicellular organisms.

Plate VI.—Figure 1. *Bacillaria paradoxa*, a wonderful diatom, common in the mud of oyster beds. These organisms are plants, the cells of which are frequently single, but are also as frequently united to each other in chains. Each cell is called a frustrule and has a shell of glass, pierced by rows of pores, through which the plant receives nourishment and through which it in some mysterious manner is able to propel itself steadily backwards and forwards. *B. paradoxa* differs from most other chains of diatom cells, in that while the frustrules adhere to each other, they at the same time can slide or travel lengthwise upon each other; thus a short chain can lengthen itself and zigzag about in a way that must be seen to be appreciated.

Figures 2 and 4.—*Nitschias,* also diatoms; at 5 are two sponge spicules; at 6 is a *vibrio,* a bacterium. A bacterial filament filled with spores is shown at 7. Figure 8 shows one of the low algæ, known as oscillatoria. This is able to bend and slide along slowly; 9 and 10 are also low forms of algæ present in the mud, on which the oyster depends so much for food.

Figure 11 is a house made of cemented grains of sand and is occupied by a rhizopod. Rhizopods are unicellular animals, made up of protoplasm in its simplest form. Such protoplasm can flow or stretch out into long projections, called pseudopods.

Figure 12 is a horny case or house of another species of rhizopod, nearly related to *Difflugia.*

Figure 13 shows six successive views of the same *Amœba* (a naked rhizopod). This species forms many long pseudopods, that are constantly being drawn back into the body and new ones formed in other parts of the body.

Figure 14 shows the outlines of another species of *Amœba* drawn every few seconds.

Figure 15 is a rhizopod, known as *Actinosphærium,* which makes a skeleton of radiating spicules. At *b* is seen two individnals uniting (conjugation), though it may be that we have here only a case of one individual multiplying or reproducing by fission (division.)

Figure 16.—*Euglena viridis,* a unicellular animal (Protozoan), showing a red stigma or "eye" at *e.*, a gullet at *g.*, a *flagellum* (lash) at *c.*, used as an organ of locomotion, and also for prehension of food. At *cv* is the contractile vacuole, a pulsating sac, used for excretory purposes.

Figure 17.—Another *Euglena,* shown in three successive phases of motion. This travels by means of a swelling forming at the front end, which travels backward like a wave, and so, pushing against the water, the animal is shoved forward.

Figures 18, 19 and 20 are three other specimens of flagellated Protozoa.

Figure 21.—Two infusors in conjugation. It is is usual to consider the smaller of the two the male, the larger the female. They are, therefore, respectively, the sperm and egg of this species of animal, which remains all life long in the egg stage, or rather, it segments (divides) after conjugation (fertilization) as does the egg, except the cells do not keep together in one body, but live independently.

FOOD OF THE OYSTER. FRONTISPIECE.

The oyster apparently has to eat all the small organisms that are in the sea water and that become entangled in the slime on its gills. Thus, the different Protoza we have shown on Plate VI. may contribute to this end, or, at any rate, they were found in the material that was being eaten by the oysters. Some of these forms retaliate by eating oyster spawn. About four-fifths of the food of the oyster consists of diatoms. The forms met with in the water on the oyster-beds are shown on our frontispiece plate.

The shell or frustrule of diatoms consists of two glassy valves that fit together like a pill-box and its cover. The top and bottom views are known as "side views;" the side is called the "front" of the frustrule.

When diatoms grow their protoplasm presses the cover valve and the box bottom apart; at the same time a girdle is produced around the line of union of the two valves, which holds the box and bottom together, while the protoplasm separates into two masses, one in the cover valve and one in the bottom valve. Then the mass in the cover secretes a new "bottom" and that in the bottom makes a new cover, and the girdle drops away, releasing the two new-formed diatom cells. In Figure 35 of the frontispiece the two upper diatoms of the chain of four show young girdles, while the parents are still united by the old girdle. The girdle is visible only in a "front" view. Single diatoms usually lie on their "sides," hut when produced in chains they show their "front" views.

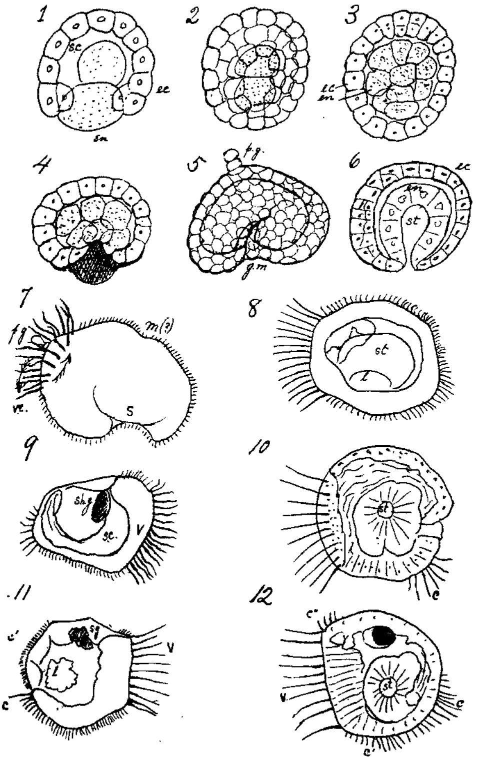
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PLATE I.

EXPLANATION OF PLATE I.

THE FORMATION OF THE GASTRULA.

Figure 1. Oyster larva, from front, 4 hours old. September 2d.
Figure 2. Oyster larva, from below.
Figure 3. Oyster larva, 5 hours old, optical horizontal section.
Figure 4. Oyster larva, 6 hours old, optical transverse section.
Figure 5. Oyster larva, 8 hours old, right side.
Figure 6. Oyster gastrula, 10 hours old, optical transverse section.
Figure 7. Oyster gastrula, 12 hours old, from right side.
Figure 8. Oyster gastrula, 23 hours old, from left side. July 30th.
Figure 9. Abnormal larva, 68 hours old. August 1st.
Figure 10. Larva, 37 hours old, from above. August 29th.
Figure 11. Abnormal larva. Same age and date.
Figure 12. Nearly normal larva, from left side.

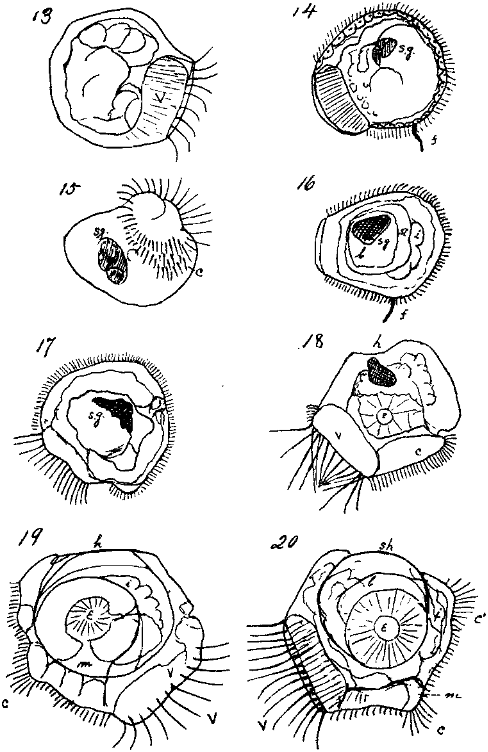


PLATE II.

EXPLANATION OF PLATE II.

THE ORIGIN OF THE SHELL.

Figure 13. Oyster veliger, one day old. July 30th.
Figure 14. Oyster larva, 40 hours old, normal. July 24th.
Figure 15. Another abnormal larva, from ventral side.
Figure 16. An abnormal larva, from left side.
Figure 17. An abnormal larva, obliquely, from above. July 24th.
Figure 18. A nearly normal larva, 37 hours old. August 28th.
Figure 19. A larva about 37 hours old, from right side.
Figure 20. A larva about 37 hours old, from left side. July 31st.

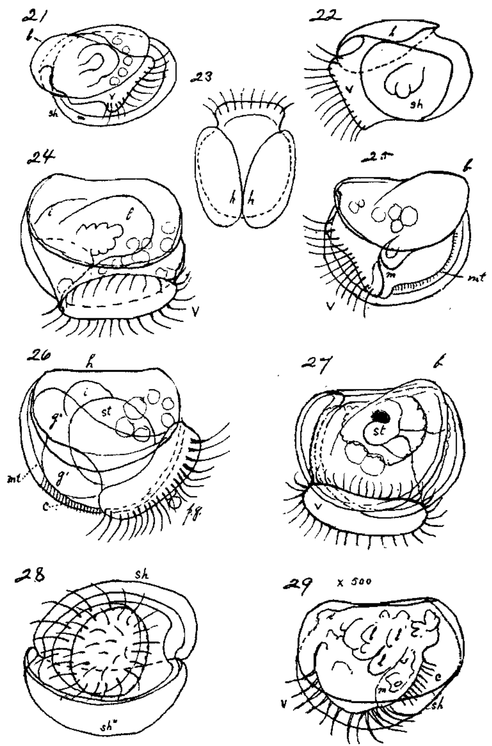


PLATE III.

EXPLANATION OF PLATE III.

COMPLETION OF THE VELIGER.

Figure 21. Oyster fry, 40 hours old, seen obliquely from right side.
Figure 22. Oblique dorsal view of oyster fry, 40 hours old. June 20th.
Figure 23. Dorsal view of oyster fry, 40 hours old.
Figure 24. *Oyster fry, same stage from right side.*
Figure 25. Oyster fry, same stage, obliquely, from front, left side.
Figure 26. Oyster fry at the beginning of third day.
Figure 27. An older oyster larva, degenerating. August 1st.
Figure 28. Oyster fry, 30 hours old, from ventral side.
Figure 29. Same larva, from the left side. August 6th.

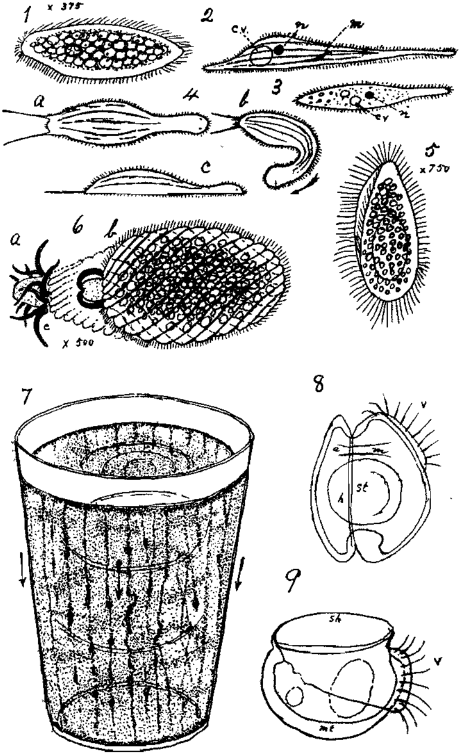


PLATE IV.

EXPLANATION OF PLATE IV.

Figure 1. Infusor sp.
Figures 2, 3. ***Amphileptus*** (?)
Figure 4. Unidentified infusor.
Figure 5. Same as 1.
Figure 6. Unidentified animalcule.
Figure 7. Tumbler of oyster fry, one day old; arrows show direction of travel of columns.
Figure 8. Ventral view of oyster fry, nearly two days old.
Figure 9. Oblique ventral view of oyster fry, nearly two days old.

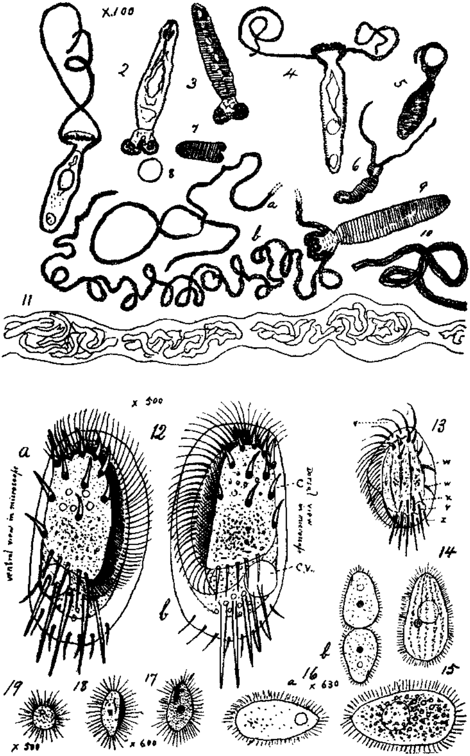
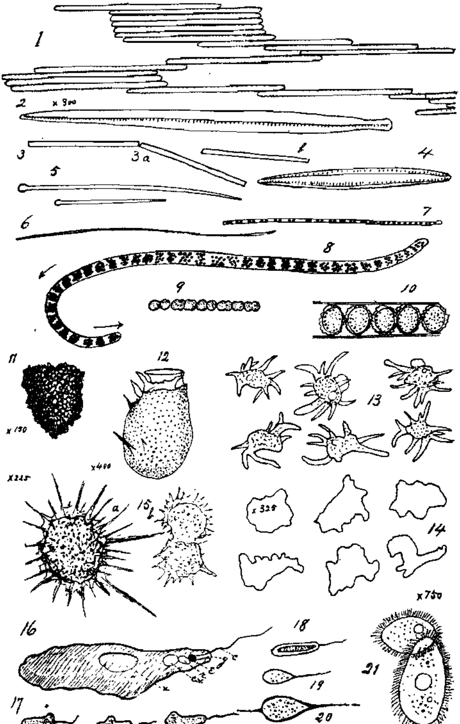

X.100
ventral view in microscope
Dorsal view in microscope
C.V.
x 500
x 630
x 600

PLATE V.

EXPLANATION OF PLATE V.

MICROSCOPIC PARASITES AND ENEMIES OF OYSTERS.

Figures 1 to 11. Gregarinoid parasites of oysters.
Figure 12, *Stylonychia* sp.
Figure 13. *Euplotes* (?)
Figures 14 to 19. Ciliated infusoria.
Figure 16*b*. Reproduction by fission.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x 750
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18
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21
17
20

PLATE VI.

EXPLANATION OF PLATE VI.

ORGANISMS PRESENT IN OYSTER FOOD.*

Figure 1. *Bacillaria paradoxa.*
Figure 2. *Nitschia* sp.
Figure 3. *Diatoma* (?).
Figure 4. *Nitschia* sp.
Figure 5. Sponge spicules.
Figure 6. Vibrion.
Figure 7. *Sporulating bacillus.*
Figure 8. Unidentified motile alga.
Figures 9, 10. Alga sp.
Figure 11. Arenaceous rhizopod (*Difflugia*).
Figure 12. Rhizopod, with siliceous shell.
Figure 13. *Amœba proteus.*
Figure 14. *Amœba* sp.
Figure 15. *Actinosphærium.*
Figure 16. *Euglena viridis.*
Figure 17. *Euglena* sp.
Figures 18, 19, 20. Flagellated infusors.
Figure 21. Conjugation of ciliated infusors.

* The principal diatom constituents of oyster food are shown on the frontispiece plate.

NOTE.—All the illustrations in this Oyster report were drawn from nature by the author.

PART II.

OBSERVATIONS ON ABORTION AND TUBERCULOSIS IN CATTLE.

As nearly all the available time of the Biologist has been occupied in studies bearing on oyster culture, the second part of our report will be brief.

We offer simply the records of abortions and cow temperatures at the tests for admission into the College Farm herd, furnished by C. B. Lane, Assistant in Dairy Husbandry, of the Station. And also the autopsies of the last survivors of the experimental herd from the tuberculosis hospital, slaughtered last March.

Nothing has been discovered that would change any of the general conclusions published by the writer in previous reports on tuberculosis. The cows that were slaughtered had been sick from tuberculosis for years, two of them since 1895. And about twenty injections of tuberculin had been made without apparently affecting the slow course of the disease. It is not denied that these repeated testings may have delayed the development of the disease. Quite apparently they did not hasten it. Reactions were present in some of the tests only, but absent in most of them.

*Record of Abortions in College Herd, November, 1901—November, 1902.

COWS.	Stall.	Age—years.	Date of purchase.	Date of service.	Date of abortion.	Months of pregnancy.	PREVIOUS SERVICE OF BULL. Cow.	PREVIOUS SERVICE OF BULL. Date.	Vitality of calf.
Regena, 3d.	26	4	Raised.	Aug. 27, 1901.	May 22, 1902.	$8\frac{25}{30}$	No. 11.	Aug. 10, 1901.	Dead
Princessa (sixth time).	30	6	Sept. 22, 1896.	Sept. 17, 1901.	May 22, 1902.	$8\frac{5}{30}$	Buttercup.	Sept. 11, 1901.	Alive; dk d
Lilith	4	5	Sept. 18, 1901.	Nov. 2, 1901.	July 19, 1902.	$8\frac{17}{30}$	No. 21.	Oct. 26, 1901.	Alive; died
† Elixir's Beauty	30	6	Raised.	Nov. 14, 1901.	Mar. 14, 1902.	4	Sebolt, 2d.	Nov. 11, 1901.	Dead.
† Elixir's Jilix	New wing.	2	Raised.	Mar. 4, 1902.	July 6, 1902.	4	30–2d.	Feb. 27, 1902.	Dead.
Diana	7	7	Nov. 4, 1901.	Mar. 7, 1902.	Oct. 9, 1902.	7	Regena.	Dec. 28, 1901.	Dead.

* By C. B. Lane.
† Daughters of Elixir, who aborted August, 1901.

AUTOPSY OF NO. 15. MARCH 31ST, 1902.

This animal, a Guernsey heifer, was tested by tuberculin injection March 11th, 1898, on admission to the College Farm herd. Its highest temperature before injection was 101.7° F.; after injection, the temperature rose to 106.6°, a very evident case of tuberculosis, and the animal was transferred to the hospital barn, being added to the tuberculous herd quarantined in that place. The following November the cow was tested the second time, the temperature rising from 101.8° to 104.6°, still an evident reaction, though smaller than on the first test.

January 4th, 1899, she was tested the third time, but the temperature record the day following the injection of the tuberculin was much lower than on the previous day and so it was declared that no reaction had occurred.

On November 5th, 1900, the cow was tested the fourth time, when her temperature maxima were 102.5° and 104.7°, respectively, somewhat of a "reaction."

On June 15th, 1901, she was tested the fifth time, but failed to show a reaction. Finally, on March 31st, 1902, she was slaughtered, and, on the dorsal margins of the two posterior lobes of her right lung, we found several clusters of small tubercles imbedded in the lung substance.

There was also a small connective tissue nodule on the liver and an irregular tubercle on the small intestine containing soft, greenish contents. Evidently she was not badly affected, and when we consider that she had been diseased for at least four years, but cannot tell whether the disease had progressed or not during this period, we must conclude that in her case either the disease was stationary or that she gave the first tremendous reaction when only incipiently affected. The question arises, did the repeated testings have any effect in retarding the disease? To answer such a query we would need a protracted series of experiments on a large herd of tuberculous animals, dividing it into two lots, one of which received treatment and the other not. Evidently, as regards No. 15, any answer would be pure guesswork.

AUTOPSY OF NO. 14. MARCH 31ST, 1902.

This was one of the original members of the hospital barn experimental herd for studying tuberculosis. Her first injection occurred at the opening of the year 1894. She showed no reaction until nearly two years later, on her sixth test. After that, reaction was shown on the tenth, thirteenth, fourteenth, eighteenth and twentieth tests, the last test, the twenty-first, June 15th, 1901, being without effect. She had therefore been diseased for seven or eight years. Physical examination in 1897 by Dr. G. F. Harker revealed "mucous râles in the dorsal portion of both lungs."

This animal was chosen as part of the hospital herd only as the result of the sixth injection in 1895. Her disease seemed to very slowly progress, but whether the injections did retard this progress or not cannot be told.

The autopsy, March 31st, 1902, revealed the presence of a large, encysted pus cavity in the posterior lobe of the left lung. In the liver was found a small, encysted tubercle with a soft center. The mediastinum was much thickened and there was an excessive growth of connective tissue surrounding the roots of the lungs. The surface of the serous membranes lining the pleural and abdominal cavities, including both surfaces of the diaphragm, were roughened and covered with a rash-like eruption. Her kidneys were enlarged and the walls of the heart were extraordinarily thin. Evidently, there was present a complication of diseases, dependent on general constitutional weakness.

AUTOPSY OF NO. 72. MARCH 31ST, 1902.

This large cow was the first and the last of the old veterans of the hospital herd. It had been tested nineteen times and given very marked reactions on the second and sixteenth injections. No reactions were present on the first, fourth, fifth, sixth, seventh, ninth, tenth, twelfth, fourteenth, fifteenth, seventeenth, eighteenth and final tests.

Autopsy showed the presence of genuine and quite extensive tubercles, but all evidences of the disease showed it to be confined to the lungs, the left worse than the right, and the posterior lobes worse than the anterior ones, about whose bronchial roots the tubercles clustered, buried in the lung tissue.

*Tuberculin Tests of Additions to College Farm Herd—1902.

Cows	Diana.		Jersey, No. 18.		Guernsey, No. 19.		† Buttercup.		Woodlawn.		Roma, 2d.		Myrtle.		Yolland.		Alta, 2d.	
Dates	Dec., 1901, 2d and 3d		Dec., 1901, 17th and 18th.		Dec., 1901, 17th and 18th		Jan., 1902, 21st and 22d.		Sept., 1902, 12th and 13th.		Sept., 1902, 12th and 13th.		Sept., 1902, 12th and 13th.		Oct., 1902, 17th and 18th.		Oct., 1902, 17th and 18th.	
5 A. M.		101.5		101.6		101.0				101.1		101.1		102.4				
6 "		101.5								101.2		100.8		102.0		100.8		101.3
7 "		101.8								101.(		100.8		101.6				
8 "		102.3		101.7		100.5				101.3		101.0		101.4		101.2		101.5
9 "		101.6		101.7		100.6	101.7	101.4		101.1		100.5		101.1				
10 "		101.7		101.8		100.7	102.0	101.5		101.2		100.7		101.8		101.3		101.6
11 "		101.4		101.8		100.7	102.2	101.5		101.7		101.0		101.6				
12 M.		101.6		101.9		100.8				101.5		100.9		101.6		101.4		101.7
1 P. M.		101.7		101.9		101.0				101.5		101.8		101.6				
2 "		101.8		101.8		101.0	102.4	102.0		101.5		101.1		101.4		101.0		101.4
3 "		101.5		102.1		101.0	102.6	101.8		101.6		100.8		101.6				
4 "	101.7	101.6		102.1		101.0	102.0	102.0		101.7		101.4		101.9	101.8	101.8	101.9	102.2
5 "	101.8	101.7	101.8	101.9	101.6	101.2			101.9	101.6	101.6	101.0	102.0	101.8				
(5:30) P. M.									(Inj.)		(Inj)		(Inj.)					
6 P. M.	101.8	101.9	101.8	102.2	101.7	101.6			102.4		101.8		102.6		102.0	101.7	101.9	102.4
															(Inj.)		(Inj.)	
7 "	101.4		101.6		101.6				102.5		101.8		102.3					
8 "	101.6		101.5		101.3				102.8		101.2		102.2		101.3		101.0	
9 "	101.8		101.3		101.5				102.7		101.6		101.7					
10 "	101.7		101.3		101.4				102.4		101.1		102.1		101.4		101.2	

*By C. B. Lane. † Not injected.

REPORT OF BOTANIST.

REPORT OF THE BOTANIST.

BYRON D. HALSTED, D.SC.
JAMES A. KELSEY, M.SC., FIELD ASSISTANT.

For the year ending November 30th, 1902, the work in the Botanical Department has been chiefly confined to experiments in the greenhouse for the winter and upon the Experiment Area during the growing season.

Owing to an enforced absence by the head of the department on account of personal illness, the field work has been in charge of Mr. J. A. Kelsey, field assistant for several years past.

Attention has been given chiefly to the breeding of truck crops, with some supplemental lines, extending into variety testing and the development of new sorts of ornamental plants.

The cross between the "Henderson" and "Burpee" dwarf lima beans has occupied considerable space, and the work of fixing the variety by selection has been in progress. Some of the reversions to the pole type have been grown and the results indicate something of value.

The cross between the "Long Purple" and "New York Improved" eggplant has been propagated largely, showing for the second year, as anticipated, considerable variation from the first type, with a tendency to go toward the "New York Improved" parent. Here selection is needed to fix the characteristics and develop a sort that is truly spineless.

The work in crossing tomatoes has gone on, and there is substantial hope of obtaining a sort that will be comparatively seedless, with remarkable vigor and uprightness of vines.

Several plots have been in crossed sweet corn, and, after four years, a combination of the "Black Mexican" and "Egyptian" is becoming established, combining the qualities of the parents in a pink variety. Some points in plant breeding have appeared in connection with the work with the corn, notably a weakness shown in albinism in connection with the in-an-in breeding.

A recent cross between the hot-house "Telegraph" cucumber, remarkable for its great length and seedlessness, and the celebrated "Znaim" variety, grown largely as a field crop in Austria, may prove of value. The work of breeding for a smooth (spineless) fruit is also progressing.

The work with a hybrid salsify is going on. Great variation is noted in vigor of plants, colors of blooms, etc., but the quality of the roots has not yet been tested.

Testing of some new importations of plants has been made.

Some of the above-mentioned lines of work were carried on in the greenhouse, and others in connection with the Experiment Area. One of the leading features of the work under glass was the testing of fungicides for a powdery mildew that is often destructive to greenhouse plants. It was found that a kerosene emulsion was a very effective remedy. It still remains to determine the most economical method of application. A study of the conditions favoring the growth of indoor mildews is needed, that rational preventive measures other than the use of fungicides may be employed.

The work with dimorphism in buckwheat was continued; also some experiments with dodders and other parasitic plants, as broom rape.

Observations as to the prevalence of the asparagus rust have been made, and, by correspondence with other station workers, some additional facts as to its habits have been obtained.

The Station herbarium has had the usual accessions from various sources during the year.

The Experiment Area.

The plan (Figure 1) upon the opposite page shows the method of plotting the Experiment Area, consisting of two acres, at the College Farm. This plan also locates the several crops that have occupied the ground during the present season.

The seven series, numbered at the top of the plan, extend up and down the slight incline of the field and are separated by four-foot paths, while the four plots, 33 by 66 feet in each series, extend right and left upon the plotted page.* Each plot is further divided the shorter way into six belts, 11 by 33 feet, as shown in the upper plot of Series 0.

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* The plan in its full details is given in the report for 1894, page 279.

The Experiment Area.

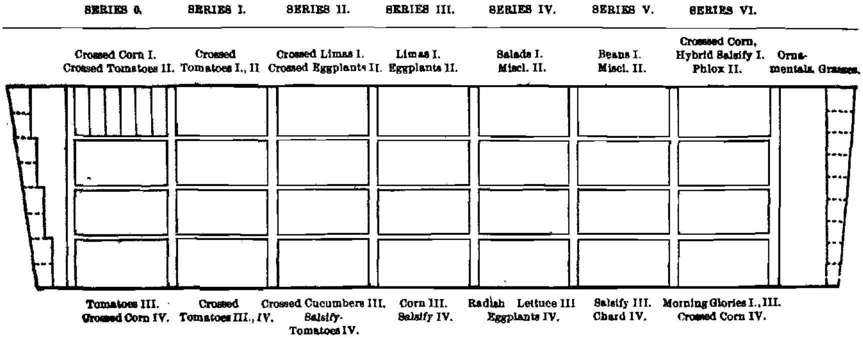

Fig. 1. The Experiment Area in 1902.

The soil, naturally gravelly clay, underlaid with yellow gravel, has been gradually improved by the addition of stable manure at the rate of twenty tons per acre for the past eight years. No other fertilizer has been used. During the winter the land has either lain bare or carried a green cover, produced by sowing rye or barley in the autumn. A special point has been made to clear up the soil after each crop and cart away and burn the refuse. The comparative freedom from disease, especially where the same crop has been grown successively upon a plot, is ascribed to this sanitary method, and is highly recommended to all engaged in growing truck crops.

EXPERIMENTS IN CROSSING SWEET CORN.

Plot IV., Series VI., was again planted with sweet corn. In belts 1 and 2 the seed used was from ears grown in the greenhouse the previous winter. These ears were from seed taken from a solid red ear, named "Extra" (X.), grown in 1901 upon the plot now under consideration. The remaining four belts were planted with grains from the ear "X.," above mentioned, and therefore, while the whole plot was planted with the product of the same ear, the first two belts bore plants one generation further from the original cross of the "Black Mexican" and the "Egyptian." In the tests for albinism (white seedlings) and other characteristics of germination, the ear in question was named "Extra" because it produced first-class plants and gave no signs of albinism.

Unlike the crop of the previous year, the plants were not large and matured more quickly than upon some of the other plots. The two belts planted with the greenhouse-grown seed produced smaller plants than the other four belts, and this was to be expected, because the plants grown in the winter under glass were slender and produced ears of only two or three inches in length, but with nearly normal diameter. The individual grains were of practically the same size as that of their parent. While the stalks in the field were below normal size, the ears were not far below those of the adjoining belts.

The first thing to be observed in the product of the two belts planted with the greenhouse-grown corn is the large number of red grains. The table below gives the number of each grains for each color for five average ears:

	Uncolored.	Black.	Red.
No. 1	15	0	365
" 2	0	0	420
" 3	36	0	360
" 4	0	0	340
" 5	20	0	380
Average	14	0	373

A similar count made for previous crop upon the same land gave—

	Uncolored.	Black.	Red.
Average 1900	172	121	92
" 1901	90	81	261

This shows that the number of red grains has greatly increased, while the white and dark grains have correspondingly decreased as a natural consequence.

The ears, while agreeing in being very nearly all red, show many differences, particularly in the number of rows of grains, and somewhat in the intensity of the red, it varying from a light pink to a dark purple. This latter variation may be in the same ear, or, upon the other hand, an ear may be solid of any one of the many shades of red.

The original red ear, "X.," was ten-rowed, those of its greenhouse progeny were ten, and the following table gives the field crop descended therefrom:

Number of 8-rowed ears	3
" " 10 " "	10
" " 12 " "	42
" " 14 " "	15
" " 16 " "	6

Belts 3, 4, 5 and 6 were planted with grains from ear "X.," above mentioned. As before stated, the plants were not quite normal size, which may be explained by the situation of the plot and peculiarities of the season. It remains to be shown whether the size and earliness are varietal peculiarities.

The following table gives the number of grains of each color for five average ears:

	Uncolored.	Black.	Red.
No. 1	60	0	444
" 2	0	0	420
" 3	10	0	550
" 4	72	0	432
" 5	0	0	480
Average	28	0	465

This is not so much of a gain in red grains as shown for the ears from the greenhouse-grown plants. This is explained above by the fact that these belts grew a crop one generation nearer to the original cross than the adjoining two belts. The greater number of grains per ear shows that upon the same plot the greenhouse-grown plants produce smaller ears than those raised in the field.

Something of the character of the ears may be gained from the following table:

Number of 8-rowed ears	6
" " 10 " "	15
" " 12 " "	38
" " 14 " "	14
" " 16 " "	6

Plate I. shows four ears from the above lot of corn. The one upon the left is untreated; the next to the right is from the greenhouse-grown seed; the next ear was close-fertilized, and the one upon the right was cross-fertilized. It remains to be seen what the relative vitality of the grains from these ears may be.

Selecting Corn for Prolificness.

The work of selecting corn for prolificness was continued the present season. Plate II. shows the two stalks that were selected in September, 1900, as the beginning of this work. One stalk is standing in its place in the plot (IV., series VI.), and another, with triple ears, is placed by its side for the photograph. It may be seen that the six ears are all evenly mixed with the dark and light grains. One stalk bore ears with eight, ten and twelve rows, respectively, and the other, ten, twelve and fourteen ears, respectively.

Samples of the results of 1901 are shown in Plate III., and the results of this selection are given upon pages 407 and 408, in the report for last year.

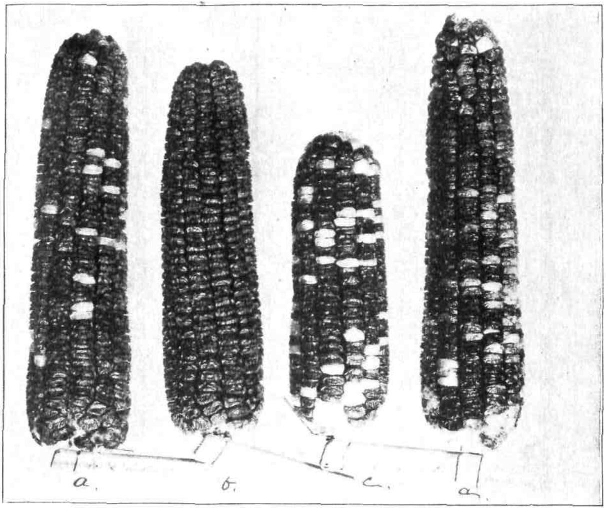

PLATE I.

PLATE II.

Prolific Corn selected for seed from the crop of crossed "Black Mexican" and "Egyptian" in 1900.

PLATE III.

Samples of Prolific Corn selected for seed from the crop of Crossed "Black Mexican" and "Egyptian" in 1901.

PLATE IV.

Samples of Prolific Corn of the crop of 1902.

During the present year a plot was given to a further study of the increase in yield of corn by selection. Plate IV. gives samples of the result. The corn of this plot was unusually large and vigorous. Single-eared stalks were rarely met with, the main portion having either two or three ears to each plant. There were numerous stalks with four and several with five ears. It is probable that the triplets will be selected for seed as the tendency to ear may be overdone. As two ears are better than one, when both are good, so three good ears are better than a large number, when the quality decreases.

The three plates show that the mixture of black and white grains is maintained without much change. The plan is to keep the two colors and let this breed, if established, be a mixed prolific.

EXPERIMENTS WITH EGGPLANTS.

Crossed Stock.

The crossed eggplants occupied Plot II., Series II., and Plot II., Series III. They were the representatives of four crossed fruits selected from the crop of 1901. Seeds were sown March 1st, and plants set in the field May 20th, three rows to a belt, eighteen plants in a row.

There seemed to be no practical difference between the crossed stock and the parent varieties as to the time of bloom or earliness of fruit; no such contrast as was remarked the preceding season.

A comparative record of the number of fruits produced by a parent and crossed stock was not kept, but the latter seemed to be fully as productive in 1901. Towards the close of the season the parent sorts ceased blooming, while the crossed were covered with flowers and young fruits up to the time of frost.

The plants received but two applications of soda-Bordeaux early in the season and so were practically unsprayed. The foliage was but lightly infested by the leaf blight, while the fruits, in common with those of the standard varieties, suffered severely.

In order to make the spraying of eggplants worth while, the applications during the fruiting season should be frequent—at least once in ten days, and oftener in case of washing rains. Perhaps of more importance than spraying is the careful removal of all fruits as soon as they are of marketable size, or of any smaller spotted fruits.

The shape of the crossed eggplant fruits seemed to be much the same as in the crop of 1901; not over 10 per cent. of the plants produced fruits strongly resembling the "N. Y. Improved" type, the remainder adhering closely to the "Combined" type of first season's crop.

A number of flowers were fertilized with pollen from the Early Long Purple this season, and the seeds of their fruits, together with seeds from others most nearly approaching the form desired, have been saved for further trials.

Variety Tests.

In Plot IV., Series IV., eighteen rows of eggplants were set, each row representing one of the following varieties:

Row 1. New York Improved Large Purple (Burpee).
" 2 Improved N. Y. Purple (Thorburn).
" 3. New Jersey Improved Long Purple (B.).
" 4. Fordhook Improved Spineless (B.).
" 5. Early Long Purple (B.).
" 6. Long Purple (Th).
" 7. Early Dwarf Round Purple (B).
" 8. Early Dwarf Purple (Th).
" 9. Black Pekin (Th.).
" 10. Round French (Th.).
" 11. Delicatesse (Th).
" 12. Black Snake (Th.).
" 13. Striped (Th.).
" 14. White Pearl (B).
" 15. Mammoth Pearl (Th.).
" *16. Round White (Th).*
" 17. Long White (Th.).
" 18. Burpee's Black Beauty (B.).

Probably the above list of eighteen is scarcely representative of eleven distinct varieties. There seemed to be no appreciable difference between Nos. 1, 2, 3 and 4. Plants of Burpee's "Black Beauty" (No. 18) were not secured until late in the season, so that only two fruits were obtained. These were of much the same shape as the "N. Y. Improved" type, except that both were rendered decidedly irregular by a sort of lateral outgrowth. In color they were noticeably darker than the latter.

Nos. 15 and 16 appeared alike, and differed from the "N. Y. Improved" type chiefly in color, and, when cooked, could be scarcely distinguished from that variety. The "Black Pekin" is smaller (one-third or one-half) and almost round, while the "N. Y. Improved" is oval in form and of a lighter purple. The "Round French" is somewhere between the "Black Pekin" and "N. Y. Improved."

The "Dwarf Round Purple" sorts (Nos. 7 and 8) were alike, with fruits small and of good quality. The "Delicatesse" (No 11) appears to us very similar to the "Dwarf Round Purple." The "Long Purple" variety of Burpee and that of Thorburn seemed the same. The fruit of the "Snake" (No. 12) was long and very slender; worthless for cooking. The "Striped" was of an oval shape and about the size of the "Round Pnrple." The "Round White" is about the size of a hen's egg; quite ornamental; only of fair quality. The "Long White" is about half as large as the "Early Long Purple;" usually curved.

EXPERIMENTS WITH TOMATOES.

The usual amount of space in the Experiment Area has been devoted to tomatoes. The chief work has been in developing the crosses that have been described in previous reports. Further progress has been made toward a type of vine of remarkable vigor and fruit, in which the seeds are much reduced. This portion of the work was fully illnstrated in the record of last year. Much difficulty is experienced in getting a combination of yellow and red color that yields a blush, and, when obtained, to have it regularly reproduced in the offspring.

OBSERVATIONS UPON SALSIFY HYBRIDS.

The third-generation plants in Half-plot I., Series VI., were from self-sown seed. Owing to their great number and irregularity, a complete color record was scarcely possible, but frequent observations were made so long as flowers were produced, and it is thought that practically all the different shades were noted and that those occurring most frequently are indicated in the following table:

	Color Chart Number.	Color.	Number of Plants.
	21	Darker red red orange	4
	22	Dark red red orange (center yellow)	2
	22	" " " " (center mottled)	5
	31	Darker red orange (center yellow)	1
	41	Darker orange red orange	1
	82	Dark yellow yellow orange	2
Parent type	93	Yellow	107
	94	Light yellow	1
	95	Lighter yellow	1
Parent type	224	Light violet red violet	150
	224	" " " " (center light)	27
	225	Lighter violet red violet	12
	233	Red violet	13
	233	" " *(center yellow)*	2
	233	" " (center mottled)	1
	234	Light red violet	12
	234	" " " (center yellow)	10
	234	" " " (center mottled)	6
	234	" " " (center drab)	8
	242	Dark red red violet	11
	242	" " " " (center yellow)	2
	242	" " " " (center mottled)	4
	243	Red red violet	27
	243	" " " (center yellow)	34
	243	" " " (center mottled)	30
	333	Red gray or russet	7
	333	" " " (center yellow)	14
	333	" " "	12
	334		2
	334	(center yellow	1
	355	Lighter yellow gray	7

The second-generation plants, grown in Half-plot IV., Series II., were the offsprings of twelve hybrids produced by crossing *Tragapogon porrifolius* L. with *Tragapogon pratensis* L. The greater part of the sowing consisted of a mixture of the seed of these twelve hybrids. Small portions of the seed of eleven plants were reserved, however, and each sowed by itself. The color of each parent plant and that of its offspring are indicated below:

Color Chart Number.		Color.	Number of Plants.
21		................(center yellow)................	..
	233	Red violet (center yellow).	1
	243	Light red violet (center yellow)	1
32		........................(center yellow)........................	..
	22	Dark red red orange	1
	25	....	1
	93	Yellow	1
	225	Lighter violet red violet (center light)	1
	233	Red violet	2
	234	Light red violet	1
	235	Lighter red violet	1
	242	Dark red red violet.	2
	243	Red red violet	10
	243	" " " (center yellow)	12
	333	Red gray or russet (center yellow)	6
51		....	..
	333	Red gray or russet (center yellow)	1
94		Light yellow	..
	93	Yellow	2
	243	Red red violet	1
95		Lighter yellow	..
	31	Darker red orange (center yellow)	2
	93	Yellow	3
	95	Lighter yellow	1
	234	Light red violet (center light)	1
	333	Red gray or russet	1
	334	....	1
	354	Light yellow gray	1
223		Violet red violet	..
	225	Lighter violet red violet (center light)	1
	233	Red violet	1
	233	" " (center light)	1
233		Red violet	..
	233	Red violet	1
	243	Red red violet	1
233		Red violet.	1
	233	Red violet	1
	234	Light red violet	1
	243	Red red violet	2
	243	" " " (center mottled)	4
384		Light violet gray	..
	234	Light red violet (center light)	1
	243	Red red violet	2

Below is given the number of plants of different shades resulting from the mixed lot of seed:

Color chart Number.	Color.	Number of Plants.
22	Dark red red orange (center mottled)	2
31	Darker red orange	1
31	" " " (center yellow)	6
41	Darker orange red orange (center yellow)	4
93	Yellow	150
223	Violet red violet	1
224	Light violet red violet	140
224	" " " " (center light)	9
225	Lighter violet red violet	1
225	" " " " (center drab)	17
233	Red violet	7
233	" " (center yellow)	10
233	" " (center mottled)	4
234	Light red violet	11
234	" " " (center light)	29
234	" " " (center mottled)	3
242	Dark red red violet	2
242	" " " " (center yellow)	3
243	Red red violet	39
243	" " " (center yellow)	30
243	" " " (center mottled)	29
333	Red gray or russet	1
333	" " " (center yellow)	20
333	" " " (center mottled)	2
334	" " " (center mottled)	3
355		1
	"Albino" plants, good size, but very pale throughout	2

Alternate rows of the two species of *Tragapogon* were sown the previous summer in Plot III., Series V.; the seed being from cross-pollenized flowers of the preceding season. Two hybrid plants appeared in 1902 in the *T. pratense* rows and six in those of *T. porrofolius*. The seed of these first-generation hybrids and selected seed of the second-generation plants in Series VI. have been sown in Plot IV., Series III.

The number of seeds produced by individual plants of the second generation has been much greater than that produced by those of the first, and plants of the third generation have been still more prolific.

EXPERIMENTS IN CROSSING LIMA BEANS.

In 1900 twenty plants were secured as probable crosses between the "Henderson" and "Burpee" dwarf lima beans. The results with the seeds from these plants are given in the report for 1901. A considerable portion of the Experiment Area has been occupied with the second generation of these crosses the present season, and the work of harvesting the crop is in progress as this report is closed. It can only be said now that there was considerable variation in the various lots, some being small-podded, prolific and early like the "Henderson" parent, while others were large-podded and comparatively late and small bearers.

Last year there were eight plants of the crosses that required poles. Seeds from these were planted separately, and, with but few exceptions, the plants have required poles. Many variations are to be met with among these, and there are indications that with careful selection a number of new pole sorts, as well as bush kinds, may be obtained in coming years. The yield upon some of the plants was quite remarkable.

CROSSED CUCUMBERS.

During last winter crosses were secured in the greenhouse of the "Telegraph" cucumber upon the "Znaim," the seeds of which were planted in Belts 1, 2 and 3 of Plot III., Series III., with good results.

The "Znaim" cucumber takes its name from a thriving Austrian town, a short distance north of Vienna, and known far and wide for the enormous quantities of superior cucumbers grown in its vicinity. Seed of this variety was kindly sent me by Mr. D. G. Fairchild, Agricultural Explorer for the U. S. Department of Agriculture. In Circular No. 2* he states that "The Znaim cucumber is a variety of *Cucumis sativus* and belongs to the field cucumber class. The seeds of this variety were brought to Znaim by a certain Andreas Lutz, servant of one of the Moravian princes. They are reported to have been introduced over one hundred years ago and to have come from the south (or Orient). The seeds were distributed throughout the county of Znaim, and from that early date the culture of this cucumber has been a lucrative one.

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*"The Cultivation of Znaim Cucumbers" Section of Seed and Plant Introduction, U. S. Department of Agriculture, January 10th, 1901.

"The statistics show that, while in 1885 only 910 acres were devoted to cucumbers in the neighborhood of Znaim, in 1895 there were fully 2,000 acres of the vegetable. The yield in 1885 was more than 150,000,000 cucumbers, while in 1895 it reached the maximum production of over 336,000,000. In the last ten years the acreage has more than doubled. The average annual yield per acre has been about 165,000 cucumbers."

The "Znaim" cucumbers were grown upon the Experiment Area in 1901, and from seed thus secured plants were obtained for the crossing in the greenhouse. The field-grown "Znaim" cucumbers were short and broad when ripe, perhaps half the length of a "White Spine," *with a rough skin that was a dull yellow in color.*

The "Telegraph" is perhaps the most popular indoor cucumber, and is remarkable for its length, seedlessness and firmness of tissue. Sometimes they are two or more feet in length; two inches in diameter.

One of the points in mind was to obtain a field cucumber of good size, with a superior flesh and a tendency to produce few seeds. Plate V. shows two average fruits much reduced in size. The texture of this crossed fruit is good, the shape is desirable and there are but few seeds. As in the "Telegraph," there are sometimes constrictions in the fruit where there are no seeds. It, of course, remains to determine whether the form will hold and the seediness prove acceptable.

Plot IV., Series II., was devoted to "White Spine"—"White Pearl" cucumbers, descending from the crosses of 1899. Seeds from several of the most striking variations of the previous season were sown, and, in the resulting crop, there seemed to be much less variation as to size and shape of fruits than in 1901. A majority of this year's fruits were smaller than the "White Spine" and larger than the "White Pearl." The plants from one of the selections of 1901 yielded fruits rather larger than the "White Spine."

In color, the crop, on the whole, seemed to show the influence of both parents, and in all the fruits examined there was the usual number of sound seeds. None of the fruits were spineless.

Cucumber Blight.—This season's plants became seriously infested with the cucumber mildew, but not until the fruits had begun to ripen.

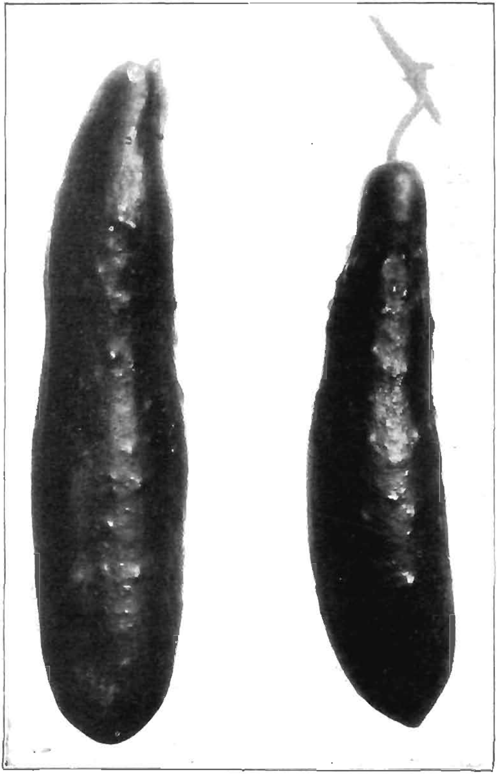

PLATE V.

Cross of "Telegraph" Cucumbers upon the "Znaim."

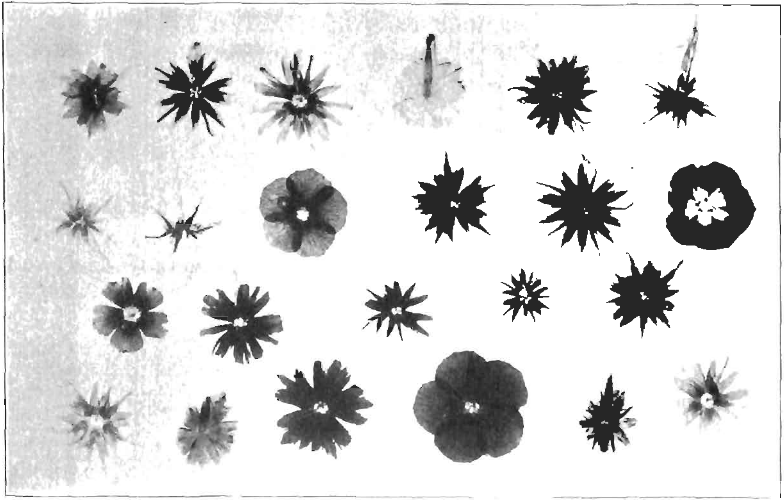

PLATE VI.

Fringed Phloxes—Various forms of flowers obtained by crossing among Phlox Drummondi.

EXPERIMENTS WITH PHLOXES.

The *Phlox Drummondii* is a native annual of great merit as an ornamental plant, and for the last two years has received attention in the Experiment Area. Twenty-four commercial varieties were grown in 1901, as listed in the report for last year. Several crosses were made in the field, and the offspring were grown to some extent in the greenhouse the following winter.

During the present season the work has been continued in the field, and a number of crosses have developed of considerable interest. The *Cuspidata* (No. 12, of 1901) variety is peculiar in having the petals extended into long teeth and giving a star-like form to the whole bloom. A number of crosses were made upon this, showing many variations of interest from the parent type. Some of these are shown in Plate VI., where the forms are easily seen, but the interesting variegation is largely lost in the photograph and engraving.

It still remains to fix some of the most attractive forms so that they will come true from seed and become satisfactory varieties for the general grower. The experience of 1901 has been repeated, namely, that the phlox is a very satisfactory ornamental plant, giving a bed of much beauty and a constant supply of handsome blooms. One can have a single solid color or ribbons of mixed shades, as the fancy suggests.

CROSSED PLANTS IN THEIR SECOND GENERATION.*

In the following statements the facts are derived entirely from observation and study of some truck crops with which breeding has been attempted during the past few years at the Experiment Grounds of the Botanical Department of the New Jersey College Experiment Station.

CORN.—In the hope of making a new variety of corn and at the same time study some of the problems in connection with plant breeding, two standard sorts were selected, one a white kind, the "Egyptian" and the "Black Mexican." It scarcely need be said that these two varieties, while both of first quality, are quite unlike in other respects than color. The "Egyptian" produces a large, white ear, with the rows of grains ten or more, while the "Mexican" has a com-

*Outline of paper prepared for meeting of the Association of American Agricultural Colleges and Experiment Stations in Washington, November 19th, 1901.

paratively small, black, eight-rowed ear, with the plant smaller and earlier maturing than the "Egyptian."

By alternating the rows of hills in the plot the first year—1899—a thorough mixture of the two was secured. As the "Egyptian" had the better style of ear for the present market, the crosses upon the "Mexican" was discarded and only the pinkish grains of the "Egyptian" were selected for planting of 1901. One plot of one-twentieth of an acre was planted entirely with the pink grains from a single ear of the "Egyptian." This proved to give a very even set of plants of universal vigor, from which fully two bushels of ears were harvested. The only thing that needs further to be said concerning this result was the exceedingly uniform nature of the ears. There were none that were with all black or all white grains, but with the white and the pink so mixed that no row of grains was far from the average *of all others upon the same ear or any other ear. As the pile lay* before me it was easy to think that a variety of corn had been established that was an unvarying mixture of white and pink grains.

From selected ears, chosen for size and shape and number of rows upon the cob, the pink grains were used for the second planting (1901) since the mingling of the two parental varieties. The same plot of ground that was in corn in 1900 was again planted, so that any variations due to surroundings might be as far as possible removed. From the first the corn was uneven, some plants growing faster than others, while 10 per cent. were albinos and did not survive beyond four weeks or so. It was observed that many of the stalks, while quite small, matured their ears and browned before others were in the silk, while at the time of harvest in September there were certain plants still green and the grain still in the "milk."

Coming now to the ears, it was evident that the pink grains were in far larger number than the previous season. There were no ears entirely white, but some of them approached in this respect the "Egyptian" type, and in shape and number of rows this parent was decidedly in evidence. On the other hand, there were some eight-rowed ears that had all the grains of the same color and that of a dark-lead shade, approaching the "Black Mexican" type. There were other stalks that bore ears with an intermixture of white and nearly black grains, there being no suggestion of pink anywhere. Still other ears were entirely pink, no white or black showing in any of the grains. As a rose-colored sweet corn was one thing in mind at the

outset, these solid-pink or pale-red ears became a hopeful indication that the end was possibly in sight.

The point that concerns us in this paper is that, while in the first year from the crossed seed the variations among the progeny was very slight and all ears showed unmistakable evidences of the cross, the same was not true to the same extent the second season. Then there was a decided tendency to depart from the form produced the year before and some plants to be small and to matnre early, like the "Mexican," having the dark, solid, eight-rowed ears of that variety, while others grew large and late, with the characteristics of the "Egyptian." While no ears were solid white, there was a tendency to unequal distribution of the color; a production of an increased percentage of the pink, and, finally, some ears were entirely of the reddish graius.

CUCUMBERS.—This is the second season with some crossing experiments with cucumbers. In 1899 the "White Spine" and "White Pearl" were crossed. The seedlings the succeeding year were comparatively uniform in plant, flower and fruit, the latter being of good size and combining the characteristics of both the parents. There was a blending of the green of the "White Spine" with the pale color of the "White Pearl," etc. The present season forty-eight hills were planted with the seeds from the crossed fruits. It made an unusually strong lot of plants, that covered the ground with a foliage that varied among the different plants, but the range of peculiarities shown by the fruits was remarkahle. They were of all colors, from the deepest green to those as white as wheat flour. Some of them were long and slender and others as round as apples. Among those with smooth skin were lying others with numerous spines, some small, other large, while not a few were striped or mottled. As the hope from the beginning was to get a smooth fruit, it looks as if the desire may be met by proper selection.

BEANS.—In 1900 a cross was obtained between the dwarf Henderson and Burpee lima beans. There were twenty of the crossed plants that in themselves differed quite widely, some adhering to the Henderson and others to the Burpee type, while many were intermediate.

During the present season seedlings of these crosses have been grown, and from the time the cotyledons appeared until the harvest the plot has shown that it was a crossed lot of plants. Among other things, seven of the plants early manifested a tendency which was gratified, and they have turned out to be pole beans differing in quality of pod,

seed, etc., from other pole limas—that is, while there was a reversion, it may be said, in the tendency to twine, the variety is not of either sort of ancestral type; in fact, no two of the pole plants are alike. One wonders what may come from the seed in coming years.

TOMATOES.—Crosses have been made between the small, upright, red-fruited "Dwarf Champion" and the large, spreading, yellow-fruited "Golden Sunrise" tomato. During the first season, out of 183 *seedlings, all except 10 came true to the mother parent, and* while it was evident that the plants were crosses, there were but few which showed remarkable peculiarities. Two were very large and produced a limited number of fruits, with comparatively few seeds. These seeds, when germinated, showed from the first a strange lot of seedlings, no two of them being alike; and most peculiar of all was the fact that many were monstrous in form, being without one cotyledon or the pumule; and such failed to live. With 40 seedlings from one of the original "Giants," a plot of ground was set, and the season's record of these plants shows a wide variation. Some were "potato-leaved," while others had foliage of a slender type; some of the plants grew entirely upright, with a very stiff stem, while others sprawled at length upon the ground; some produced red fruits of large size and others with the size of cherries, while one was plum-shape. The yellow-fruited plants were nearly as numerous and variable.

EGGPLANTS.—Last year a cross was effected between two varieties of eggplant, namely, the "Long Purple" and the "New York Improved Spineless." These were reciprocal, the combination being to improve the quality of the "N. Y. Improved" by a union with one of small size and high quality. During this season a large number of the crosses have been raised, and the most noticeable feature of them is their nearly uniform character, whether the cross was made in one direction or its opposite. In passing, it may be also stated that the vigor of the plants was remarkable, the yield large, of fruit of high quality, *and a handsome, long, pear shape, with the seeds all well down toward* the blossom end. So satisfactory has this cross been the first season that all growers who have seen the plants desire some of the seed. It has been withheld upon the ground of a doubt as to its fixedness. It is not unlikely that another year will show many deviations, so that selecting will be required to establish the cross even more than one variety should they be desired.

SALISFY.—All of the above instances of plant breeding have been

unions between varieties of the same species—that is, crosses. With the salsify the combination has been between two species, and the result is a genuine hybrid. The two parents in this instance were the garden salsify and the wild species. The two agree in many characteristics, but are widely different in the flower, particularly the color, which is a shade of violet in the garden sort and unmixed yellow in the other. Last year, in their first season, the hybrid plants were easily recognized by a combination of the qualities of the two species, but most readily of all by the color of the flowers, which was dark red violet. There were two types of these direct hybrids, differing only in the amount of yellow in the center of the head—that is, there were the purple red clusters and those that in distinction may be termed yellow-eyed. The type was constant upon any one plant, and number of each type was about equal. Coming to the seedlings from these plants that were grown by the hundred this past season, the case is quite different, and no less than thirty-six colors or hues found, as determined by Prang's color chart. Of these the thirteen with larger numbers out of 200 plants examined are as follows: Yellow, 10; light yellow, 12; lighter yellow, 6; darker orange red orange, 9; darker red orange, 6; darker red, 23; dark red, 13; light red violet, 9; lighter red violet, 7; violet red violet, 23; light violet red violet, 35; lighter violet red violet, 29; dark violet gray, 6. Both parents are represented and many intergrades, but the garden salsify has 103 violet reds to 28 plants that represent the yellows of the wild species. It is seen that while the first year there were two uniform types as to colors, in the second season it is far otherwise. In short, there was a wide diversity, with a strong tendency to return to the parent forms, but at the same time many intermediates.

All of the cases cited show that the second generation is the earliest moment when the real results of the cross show themselves, after which the fixing of the desired new forms must begin by selecting further breeding with one or other parent form by inbreeding or a combination of all these means.

EXPERIMENTS WITH LAWN GRASSES.

The nine plots of grass selected in the spring of 1896 have been kept closely cut with the lawn-mower during each season, and notes made from time to time upon the condition of each plot. The following table shows the species of seed sown in each plot, and the condition of the stand of grass, in percentage, for the past seven years:

Plot.		1896.	1897.	1898.	1899.	1900.	1901.	1902.
1.	Meadow Fescue (*Festuca pratensis* Huds.)......	90	50	40	45	55	60	60
2.	Fine-leaved Fescue (*Festuca tenuifolia* Sib.)...	5	50	40	40	40	45	45
3.	Sheep's Fescue (*Festuca ovina* L.)..	10	50	40	40	30	25	40
4.	Rhode Island Bent (*Agrostis canina* L.).........	80	80	90	90	90	95	95
5.	Wood Meadow (*Poa nemoralis* L.)...............	60	65	70	85	80	85	90
6.	Kentucky Blue (*Poa pratensis* L.)................	50	65	90	90	85	85	80
7.	Rough Meadow (*Poa trivalis* L.).................	90	65	70	70	45	70	60
8.	Redtop (*Agrostis alba vulgaris* With.)............	100	90	70	60	25	25	20
9.	Perennial Rye (*Lolium perenne* L.)...............	100	85	70	40	20	15	15

It is seen that the "Rhode Island Bent" holds up well, and the stand this autumn, at time of last inspection, was near perfection. In the dry weeks of summer it becomes brown, and for this reason the present rating may be high. It is exceptionally fine in texture. The "Kentucky Blue Grass" has proved very satisfactory for the last three years, but some weeds have crept in the present season and lowered the percentage somewhat. In the "Wood Meadow" plot the grass has held its place for three seasons. The "Meadow Fescue" has made a gain this season over the previous year. Being at one end of the rows of plots, it is favored by a border gutter along the side of the plot. The "Redtop" shows a poor stand and the "Perennial Rye Grass" is nearly gone out. The leading weed in autumn is the crab grass, that fills in all vacancies. There are some dandelions that have not been removed from these test grounds.

EXPERIMENTS WITH WEEDS.

A piece of ground 11 by 33 feet, called "the weed belt," has been continued for the sixth season.

The fourteen most prominent weeds in this neglected area in 1902 were the following:

1. *Rumex acetosella* L. (0), (7), (4), (3), (1), (1).
2. *Daucus Carota* L. (12), (0), (0), (4), (5).
3. *Bromus racemosus* L. (0), (0), (0), (0), (2).
4. *Polygonum Pennsylvanicum* L. (0), (6), (3), (2), (2), (4).
5. *Abutilon Abutilon* L. (7), (2), (6), (6), (8).
6. *Chrysanthemum Leucanthemum* L. (0), (0), (0), (9), (6).
7. *Silene noctiflora* L. (9), (13), (14), (7), (7).
8. *Taraxacum Taraxacum* L. (0), (0), (9), (5), (8).
9. *Convolvulus arvensis* L. (0), (0), (0), (0), (9).
10. *Melilotus alba* Lam. (0), (0), (0), (12), (10).
11. *Oxalis stricta* L. (0), (0), (0), (8), (11).
12. *Ambrosia artemisiaefolia* L. (3), (5), (1), (1), (14).
13. *Aster* Sp.
14. *Rudbeckia hirta* L. (0), (0), (0), (0), (13).

The number in parentheses indicates the rank that each kind of weed held in previous years, beginning in 1897.

Other weeds, arranged in the order of their importance, were—

1. *Chenopodium album* L.
2. *Plantago Rugelii* L.
3. *Rumex crispus* L.
4. *Arctium Lappa* L.
5. *Panicum sanguinale* L.
6. *Barbarea Barbarea* (L.)
7. *Hibiscus Trionum* L.
8. *Polygonum Convolvulus* L.
9. *Acalypha Virginica* L.
10. *Amarantus retroflexus* L.
11. *Plantago lanceolata* L.
12. *Ixophorus glaucus* (L.)
13. *Aster*, 2 species.
14. *Tragapogon pratensis* L.
15. *Tragapogon porrofolius* L.

Trifolium repens and *T. hybridum* were prominent in 1901 and were equally conspicuous the present season. Occasional plants of *T. pratense* were observed; one tomato plant, a three-year old grape vine and a young cherry tree.

Weed Notes.

HORSE-NETTLE (*S. Carolinense* L.).—Mr. Polhemus, of Rocky Hill, handed the Director a specimen of this weed for identification, stating that it was becoming troublesome in the meadows in his neighborhood.

CORN CHAMOMILE (*A. arvensis* L.).—The manner in which this plant can adapt itself to conditions may be seen in one portion of the College campus. Instead of being destroyed by frequent clippings of the lawn-mower, its usually erect or nearly erect stems have become prostrate. Roots are put forth from their joints, binding them closely to the ground, and one plant will spread over a considerable area in a single season.

GROUND IVY (*N. Glechoma* Benth.).—In some of the lawns about New Brunswick this weed is becoming quite conspicuous.

AILANTHUS (*A. glandulosus* Desf.).—The owner of a lawn containing a few ailanthus trees is annoyed during late summer and fall by the great number of ailanthus seedlings. One of the trees was cut down in the spring, and from its large "surface" roots many sprouts were sent up throughout the season.

NOTES UPON CLUB-ROOT.

Since the announcement of the proposition that the cancer in the human subject, particularly of the stomach, is due to an organism closely related to and perhaps indentical with the *Plasmodiophora Brassicæ* Wor., there has been a new importance placed upon the club-root fungus.

Fig. 2.
Club-root of Radish.

In case of the cabbage, the root is not eaten, and the edible portion of the "head" is rarely if ever infested by the organism causing the offensive cancerous growths in the root systems. With turnips, which are equally infested with the disease, the germs might find ready access to the alimentary canal. In the process of cooking it is probable that the fungus would be killed, but children are fond of raw roots, and, thus eaten, they might cause the lodgment of the live germs, where they, perhaps, would prove mischievous. Any badly-diseased turnip would naturally be rejected by all, but it is in those very slightly diseased that resides the most danger. In cutting away of an excrescence from an otherwise normal turnip there might be quite a portion of the infested tissue left behind, which, when eaten raw or after partial cooking, might prove injurious.

Radishes are usually eaten raw, and thus the germs might be introduced, especially when the fungus does not produce any striking distortion and the root seems unaffected. This latter is usually the

case with radishes, but that they are subject to the club-root disease is shown by *the accompanying engraving (Fig. 2) of a specimen grown* upon the trial grounds the present season. In this instance only the slender, lower portion of the root shows the galls, but not unlikely the edible part is also infested.

So long as there is strong suspicions that cancer is induced by the club-root germs in the roots of turnips, radishes and other cruciferous plants, it is well for people to be upon their guard and eat only healthy roots.

THE MILDEW OF LIMA BEANS.

Late in September numerous complaints of trouble with lima beans, with specimens, were sent in to the Station. The disease proved to be the mildew (*Phytophthora Phaseoli* Thax.) and merits a consideration here as being among the most destructive of the fungus troubles of the year.

The following is from Bulletin No. 151:* "This fungus was first described by Dr. Thaxter† and later more fully‡ considered by him, with engravings, some of which are herewith reproduced through the courtesy of the Connecticut Experiment Station. While the fungus is very easily seen in itself and also indirectly prominent from the destruction it produces upon the affected lima bean plants, its native home is somewhat of a puzzle, as evidenced by the following lines, written by its discoverer: 'Its origin * * * is purely a matter of conjecture, since, although it seems scarcely probable that so conspicuous a form should have been overlooked in so thoroughly explored a region as the New England and adjacent States, it has been equally overlooked in other parts of the world, if indeed it is a foreign importation.' "

It was not long before the mildew was met with in other States, and at the present time it is a serious menace to the growers of lima beans in New Jersey. The records show, for example, that the disease has been abundant in Bergen county. "Here the pole limas were so badly attacked that few or no pods were picked from some of the

* "Bean Diseases and Their Remedies."

† Botanical Gazette, vol. 14, p. 273, November, 1889.

‡ Conn. Agr. Exper. Rept., 13, 1889, pp. 167–170.

fields. The mildew was worse with plants growing upon rich lowlands and where the same crop had been upon the ground the previous year."* Not only the young pods, but the whole flower clusters were

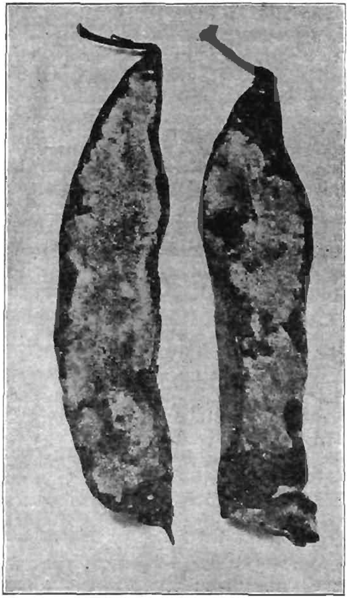

Fig. 3.
Lima Beans Affected with Mildew.

destroyed, and the dead tips of these stood up above the surrounding leaves of the affected plants. The general appearance of the mildewed pods is shown in Figure 3, the engraving having been made

* Rept. N. J. Exper. Sta., 1897, p. 297.

from a photograph of two diseased pods, while the ruined flower clusters are similarly shown in Figure 4.

A microscopic examination of the affected part of the plant shows that it is penetrated by the slender threads of the fungus, which come

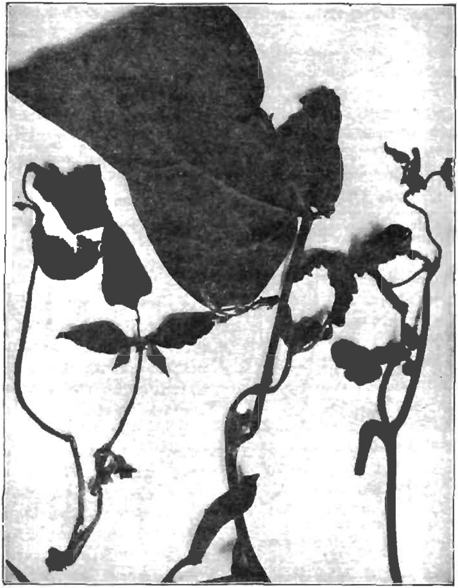

Fig. 4.
Lima Bean Flowers Ruined by Mildew.

to the surface and there produce tufts of branching filaments and bear multitudes of spores, all of which constitute the light mouldy covering and suggests the common name of downy mildew that is given to many members of this family. For example, there is a closely-related

mildew of the grape, another of indoor lettuce, another of onions, while the potato-rot fungus, often extremely destructive, is very near of kin to the bean *Phytophthora*. Figure 5 gives some of the microscopic details of the mildew. At *a* is shown a portion of the diseased bean pod with the threads passing through the stoma and bearing the spores upon their tips. A more enlarged view of the mildew is shown at *b*. The enemy in question belongs to a group of fungi the members of which are among the most fatal of all that afflict crop plants, and therefore demand prompt attention upon the part of the grower when met with.

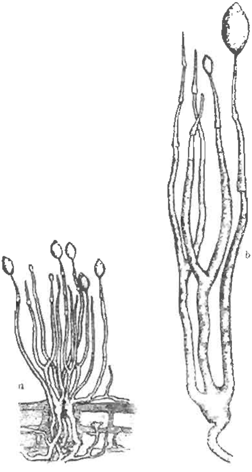

Fig. 5.
Microscopic Details of the Mildew.

Precautions.—Some hints as to precautionary measures may be gained by a knowledge of the habits of the group to which the mildew of the lima beans belongs. After a somewhat prolonged study of the relation obtaining between the weather and the development of fungi, it may be confidently asserted that there is no group that is more influenced by prevailing moisture than the downy mildews. The potato-rot fungus (*Phytophthora infestans* DeBy.) is particularly fond of wet weather, with high temperature, and the records show that 1899, the year when the bean Phytophthora was discovered, was remarkable for its excessive summer and autumn rains. In the case of greenhouse lettuce it is found that sub-irrigation is almost a complete preventive of the mildew, otherwise often quite destructive. It is safe to assume, therefore, that the amount of the bean mildew will depend quite largely upon the amount of moisture, and, in a dry season, but little damage may be expected from it. But the rains cannot

be controlled, and therefore the factor of precipitation remains an uncertainty. This much can become a practical matter, namely, the shunning of all lowlands that are apt to be wet. In other words, favor the higher and drier land for lima beans, because in such situations the mildew will be less certain to gain a foothold.

Dr. Sturgis* concludes his report of the remedies for the mildew as follows: "While from the nature of the disease it would seem probable that the use of fungicides would present many difficulties, yet, from experiments in which Bordeaux mixture, ammoniacal copper carbonate solution, sulphur and potassium sulphide were used, it appeared that when three applications of Bordeaux mixture was followed by two applications of ammoniacal copper carbonate solution the amount of the disease was greatly reduced.

"The conclusions drawn from the experiments with fungicides show that even in a season most favorable for the lima bean mildew, a thorough treatment of the vines with Bordeaux mixture will insure a crop. The selection of well-drained land and a light soil, reducing the number of vines in the hill and planting the poles erect, will insure conditions as little favorable to the development of the fungus as possible."

THE ASPARAGUS RUST.

In our own State, the following may stand as representative for the *region centering in Middletown, Monmouth county, where large areas* are devoted to asparagus for the New York market. Mr. James C. Hendrickson reports: "The asparagus fields look unusually well for this time of year. There has been very little rust this fall. Most of the 'Colossal' beds are gone. The 'French' and 'Palmetto' beds are now showing a little rust. I do not see much difference; if any, it is slightly in favor of the 'French' sort. The crop, I think, has been an average one considering the past six years." Mr. Charles Tindall, of New Monmouth, writes that "The crop was larger than the previous year, partly on acconnt of warmer weather and sufficient moisture in May; also because of less rust in the fall before. The quality was also good. The growth of top is not as heavy as last year, caused by the dry weather at the time of plowing off the beds the last of June. The rust made its appearance about the first of September in a light form, but too late to materially affect the crop, excepting where it was

* Report Conn. Exper. Sta. 1897, pp. 159–160.

neglected in cultivation or badly infested with the beetle. To my knowledge there are only the two varieties in this section, 'Palmetto' and 'French Argenteuil,' and, so far as I have been able to ascertain, there is no material difference in regard to the rust, both being affected about the same. Seedlings that have been cared for well are practically free from rust and are looking very well."

For the southern section, providing asparagus for the Philadelphia market, Mr. John G. Whitall, of Woodbury, writes: "The crop the past season was a fair one, but the rust is now probably worse than ever before, many of the fields being entirely dead. The rust did not make its appearance as early in the season as usual, but since appearing has been very destructive. The 'Palmetto' does not show the effects of the rust nearly as badly as other varieties. In one or two cases, where beds of 'Palmetto' have been kept entirely free from grass and weeds, the rust does not seem as bad as where these have been allowed to grow."

For Vermont, Mr. W. J. Morse, Assistant Botanist of the Experiment Station, reports: "We have been on the lookout for it for several days and have found very little of it, where in years past it has been quite prevalent. Professor Jones is of the opinion, therefore, that it is not occurring as much in this locality this year as usual."

For Massachusetts, Professor Stone writes: "I think I can say, in general, that this year has been a very good one for asparagus. By that I mean there has been very little rust. We have had plenty of rain all through the season, and, according to my theory of rust infection, we should not expect much in such a season. I know that they have it on Cape Cod to some extent, but one large grower told me that it was far less than during other seasons. Our beds at the College at the present time do not show a particle of the fall stage. I saw a good illustration of spraying this summer with Bordeaux mixture alone. One small bed was divided into two sections, one-half of which was sprayed and the other half not. The gain on the sprayed portion was enormous compared with the unsprayed. This was done by a man who owns sixteen or seventeen acres of asparagus, and he certainly covered his plants thoroughly with Bordeaux. They were covered so thoroughly with Bordeaux, large and small branches, that they had the appearance of a blue spruce. This experiment convinces me that if plants are thoroughly covered, every portion of them, with the Bordeaux mixture, that good results can be obtained. The difficulty

has been, however, to thoroughly cover the plants with Bordeaux mixture."

Professor Stewart writes for New York: "I am sorry to say that I can give you little definite information except for eastern Long Island. I have just returned from a trip to that section, and I find that there the rust is somewhat more destructive than it was in 1901. Many of the young buds are considerably injured by the disease, the plants being already dead or brown, but the majority of the older beds are only moderately affected and are still very largely green. The few beds which I have observed in Central New York are very slightly affected, and my impression is that there is not much of the disease in this part of the State."

From Delaware, Professor Chester reports as follows: "I have found the rust generally prevalent throughout Delaware during the present season, but probably not more abundant than last year. I have, however, only general impressions to convey on the subject."

Professor Buckhout writes for Pennsylvania: "Up to the time of receiving your letter I had not noticed any asparagus rust on our bed, hut on looking it over to-day I find there is qnite a showing, though hardly so much as in previous years; certainly no more. I may say that we have done no spraying aud that our bed is small, scarcely, if any, over one-fourth acre. The general course of the growing season has been as follows: A dryer than usual spring, culminating with unsasonably dry, dusty weather up to June 10th. Rain then began and was almost daily until about July 15th to 20th, when there was a gradual diminishing until August 1st. August was midsummer dryness, unbroken by rain until September 12th, but no rains of consequence until September 25th."

For Virginia, Professor Alwood sends the following: "This year the asparagus rust has appeared in our plantations here. As it appeared in some young plants set last spring, I have no hesitancy in saying that the fungus must have been brought from the nursery. These plants were purchased at a small nursery near Richmond, which would go to show that the territory is infested; and I doubt not that this disease is prevalent about Richmond, as it is at some points along the coast."

Professor Selby reports for Ohio: "I can give you but little new information concerning asparagus rust. Indeed, I have no definite notes save the general one that it has become spread over almost the entire State, locally."

Professor Arthur reports from Indiana: "The rust in Indiana did not appear very early this season, but it was general, probably few or no patches of plants escaping. While destructive, it does not seem to have been uncommonly so, as might have been supposed from the wet season. No æcida have yet been found within the State. Here at Spirit Lake (Iowa) I find the rust, but there is so little of it as to be economically unimportant. At Decorah, Iowa, as you may be aware, Mr. Holway found æcida on onion leaves, close to rusted asparagus plants (and nowhere else), which, in the light of Mr. Sheldon's studies (reported in *Science*), appears to indicate that asparagus rust is not confined to a single genus of host plants, at least in the æcidial stage. Whether *Puccinia Porri* is identical with *Puccinia Asparagi* or not it would be rash to say. It is safer at present to assume that they are distinct, but that the latter may occasionally produce æcidia on onion almost or quite like the æcidium of *P. Porri* in morphological characters."

Doctor Burrell reports for Illinois: "The asparagus rust has appeared in many new places in various parts of Illinois during the last year, and it has been found within that time in quite a number of places where it had been earlier introduced, but of which we had no previous knowledge. I think, all told, there must be at least one hundred separate locations of the disease now in our State. I have had no practical experience in combatting it and have no definite knowledge as to its extermination within our borders. It is true, however, that certain statements have been made by practical growers, going to show that they have kept it down by spraying with Bordeaux mixture. I have no definite evidence concerning anything about the disease now *save this fact—that it is evidently increasing considerably with us, and* I think it is doing a good deal of damage."

For Iowa, Professor Pammel writes: "The *Puccinia Asparagi* is on the increase, but I have no extensive reports from other sections of the State, and I notice that additional plots are affected in this vicinity."

Professor Bessey writes for Nebraska: "Mr. John L. Sheldon, Instructor in Botany in the School of Agriculture, who has made this rust a special study for a number of years, says that there is not as much this year as last. In regard to the possible connection between the abundance of rust this year and the peculiarities of the season, he says that of course this season has been wet and the rust less abundant. Whether there is any connection between these two points he is not

prepared to say. However, he says that there is less rust on low land than on high land, and you may put this fact with the other and make what you can out of it. Many people burn the brush at the end of the year, and where this is done there is now little or no rust. In some instances the owners, after burning the brush, run over the ground with a disc cultivator, and this seems to do some good also. In a particular case, near Lincoln, the asparagus is grown in an orchard where burning and other precautions cannot be resorted to, and it is a fact that there is more rust in this asparagus plot than elsewhere. Still the season is one which is characterized by a small amount of rust on the asparagus."

Professor W. R. Shaw reports for Oklahoma: "I have neither seen any of the rust nor received any report of its occurrence in Oklahoma and Indian Territories, and Mr. Morris, our Horticulturist, informs me that he has never met with this rust in this region."

Professor Saunders sends the following for South Dakota: "I have nothing in particular to report with reference to the asparagus rust. The only two patches of asparagus that I know of were so badly infested last year that they were plowed up and destroyed last fall. A few scattering volunteers in our timber claim were quite as badly infested this year as was the patch of asparagus last year."

For North Dakota, Professor Bolley sends the following: "This time I am able to report to you that the asparagus rust is here with a vengeance. I am unable to give you any information regarding the influence of weather upon the disease. Last year we had a very dry season. The plot at the College, which is a large one, rusted some time in August, so as to be thoroughly brown. This spring has been an extremely wet one, so there was an abundance of moisture in the ground at all periods of the growing season, and this College bed was struck by rust so as to be thoroughly killed by the 15th of August, so dead that we cut it all down and are making some experiments as to the further effect of the rust, how to control it, etc. This bed at the College is one of the oldest asparagus beds in the country and has become thoroughly infested. Last year, on my own lawn, my bed of asparagus was killed by rust. I pulled all of the old stalks out of the bed, burned them up and covered it with ashes. The bed this year has borne no rust, but I simply consider it an accident; do not know why the plants have staid green until frost. The rust is spreading through the State, I know, because I have found it upon volunteer asparagus on numerous tree claims."

Professor Nelson makes a favorable report for Wyoming: "I again have the pleasure of reporting that the asparagus rust has not made its appearance in this State so far as I have been informed."

Professor Balmer, of Washington, sends the following: "I have seen no asparagus rust in this State, nor have I heard of any."

For California, J. J. Keegan, Secretary of the State Board of Horticulture, writes: "I beg leave to acknowledge receipt of your reports for 1899, 1900 and 1901, for which please accept my thanks. The information they convey will be of the greatest value to this Board.

"We are trying by all means in our power to prevent the introduction of the asparagus rust into this State. This Board has passed a resolution prohibiting the introduction of all asparagus roots and seeds from any place outside of California into this State. By this means we hope to escape it.

"The asparagus industry is rapidly becoming of the greatest importance, fields of 1,000 acres and upwards having been planted on the islands in the delta of the Sacramento and San Joaquin rivers, and the coming season many more will be added. Should the rust be introduced it would all be ruined, as the islands are very low and moist, protected by levees from overflow and most favorable to the propagation of fungus growths."

Asparagus Rust on the College Farm.

On October 23d a final inspection was made of the several varieties in the four plots. The field generally showed much rust and the brush was not vigorous. The larger size and deeper green of the "Palmetto" variety was evident from all parts of the field. The "Argenteuil" was little infested. Upon a basis of percentages, as assigned to the amount of rust in former years, the "Palmetto" and "Argenteuil" show 25 per cent., while the "Mammoth," "Elmira," "Columbian," "Colossal," "Brunswick" and "Cross-bred" have 75 per cent. of rusting.

Last year the percentages were 20 and 50. It was noted that the least rust was upon the plot where barnyard manure had been applied.

BROOM-RAPE UPON COLEUS.

The greenhouse during last winter was employed in part in testing the habits of certain seed-bearing parasites, as the dodders and brōom-rape. It is interesting to note that a coleus plant standing near these

PLATE VII.

Coleus Plant in pot showing Broom-rape Parasite in Bloom near the soil.

experiments became infested with the species of broom-rape (*Orobanche ramosa* L.) that is sometimes quite destructive to the tobacco and hemp, particularly in Kentucky.*

Last year specimens were met with upon tomato,† which is a host closely related to the tobacco. In this instance the host is a member of the mint family and shows that this root parasite has quite a wide range of plants upon which it may possibly flourish. Plate VII. shows the potted coleus plant and the broom-rape that is growing upon it below the surface of the earth.

EXPERIMENTS IN GERMINATION OF CORN.

Thirty-two lots of corn were germinated with as little moisture in the soil as possible. Only lots Nos. 9, 10, 25 and 31 gave albinos. A duplicate set was grown in very moist earth, with the result that Nos. 9, 10, 22, 25 and 31 gave albinos. There was one albino plant in No. 22; otherwise, the numbers giving albinos were the same in the two lots. This would indicate that the albinism is in the seed or at least not induced by the amount of moisture in germination.

A considerable lot of small ears ("nubbins"), mostly immature, were placed upon moist moss and the scattered grains germinated. An albino seedling was a rare exception. This indicates that immaturity of the grains is not a condition for albinism.

Ears yielding albinos were selected and twenty grains from each row planted.

No. 1.			No. 2.			No. 3.			No. 4.		
Row.	Albinos.	Green.	Row.	Albinos.	Green.	Row.	Albinos.	Green.	Row.	Albinos	Green
1...	1	19	1...	3	17	1...	1	19	1...	3	19
2...	2	16	2...	2	18	2...	2	18	2...	2	16
3...	..	19	3...	4	14	3...	..	20	3...	4	16
4...	5	14	4...	1	18	4...	4	16	4...	1	18
5...	2	18	5...	3	16	5...	2	18	5...	3	16
6...	..	18	6...	5	14	6...	..	20	6...	4	15

This indicates that the albinos are not confined to certain pairs of rows on the ear.

* Bulletin 24, Kentucky Experiment Station, 1890.

† Report for 1901, p. 435.

Tests were made of grains from ears when there were three (triplets) upon the stalk:

		Albinos.	Green.
No. 1.	Oldest ear	..	20
" 2.	Middle "	..	20
" 3.	Youngest "	..	16
" 4.		1	14
" 5.		1	15
" 6.		..	1
" 7.		..	2
" 8.		..	18
" 9.		..	14
" 10.		..	20
" 11.		..	17
" 12.		..	17

Here there were only two albinos, and both from ears of the same plant. These were the oldest and the middle ear upon the stalk.

A larger test was made of grains from ears where there were two (twins) upon the stalk:

		Albinos.	Green.		Albinos.	Green.
No. 1.	Older	..	17	No. 1	3	9
" 2.	Younger	..	20	" 2	1	18
" 3.		7	12	" 3	..	13
" 4.		3	14	" 4	1	19
" 5.		..	20	" 5	1	18
" 6.		..	18	" 6	7	9
" 7.		..	17	" 7	2	18
" 8.		..	17	" 8	1	11
" 9.		2	16	" 9	..	20
" 10.		..	19	" 10	..	20
" 11.		..	14	" 11	..	18
" 12.		2	12	" 12	..	18
" 13.		..	7	" 13	4	14
" 14.		..	15	" 14	2	17
" 15.		..	16	" 15	..	20
" 16.		..	15	" 16	..	20
" 17.		..	19	" 17	..	19
" 18.		..	18	" 18	..	18
" 19.		..	18	" 19	..	20
" 20.		..	9	" 20	..	7

In the first set only four ears yield albinos, two of which are the older and two the younger ears upon the stalk. It is to be observed that the majority of all the white seedlings came from the second pair of twins (Nos. 3 and 4) where both ears gave albinos.

In the second set nine ears gave albinos, four being of the older and five of the younger ears. It is to be noted that in all instances but one where one ear of a pair showed albinism, the other also did the same. This indicates that the whole plant is affected.

Special test of prolific corn was made as follows, twenty grains in a planting from each year:

	Ear.	Albinos.	Green.		Ear.	Albinos.	Green.
Plant 1.....	A	3	17	Plant 6.....	A	..	20
	B	2	16		B	..	20
	C	1	19		C	..	20
Plant 2.....	A	..	20	Plant 7.....	A	3	16
	B	..	18		B	1	18
	C	..	16		C	..	19
Plant 3.....	A	5	12	Plant 8....	A	1	19
	B	2	16		B	1	19
	C	5	13		C	1	19
Plant 4.....	A	..	20	Plant 9.....	A	1	19
	B	..	19		B	2	18
	C	..	17		C	7	13
					D	2	16
					E	3	17
Plant 5.....	A	..	20				
	B	..	20				
	C	..	18				
	D	..	17				

In this test it is noted that when one ear of the set of three to five from a stalk showed albinism, the others did also, with but a single exception. Plants 2, 4, 5 and 6 gave no albinos. The oldest ears (A) gave 3, 5, 3, 1 and 1 white seedlings, respectively, or a total of 13. The next oldest gave 2, 2, 1, 1, 2, or a total of 8. The third ear gave 1, 5, 1 and 7, or 14. The single fourth ear gave 2 and the fifth ear 3 albinos.

The white seedlings do not seem to be attributed to over bearing of the stalk or to age of the ear when twins or triplets are produced.

Several tests were made of inbred corn in contract with wide-bred ears. The former received only the pollen of the same plant, while the latter has the tassels removed before the silks were receptive.

Inbred Corn.	Albinos.	Green.
No. 1	13	47
" 2	15	38
" 3	7	48

Wide-bred Corn.	Green.
No. 1	60
" 2	65
" 3	65

There were seventy grains planted at four different times from each of the six ears. Of the inbred corn over a quarter were albinos, while none appeared among the two hundred seedlings of the wide-hred grains.

Plate VIII. shows the plants in one of the tests when two weeks old. Rows 2 and 3 are particularly poor, as shown in contract with the plants in row 4. The albinos, although present, are not easily seen in the engraving.

The number of tests in all the above-mentioned germinations is too small to warrant any conclusion, but the results as a whole point towards close fertilization as the cause. It would be well for all growers of corn to detassel the plants from which the seed ears are afterwards selected.

ON THE BEHAVIOR OF MUTILATED SEEDLINGS.*

The particular form of mutilation of seedlings here considered is that of the removal of the plumule. Several kinds of plants have been tested during the last twelve months in the deplumuling of the young seedlings. The first of these was the garden radish, representing a small, large-rooted and short-lived plant. Soon after the seedling was above ground the pumule was removed upon alternate rows of plants, while the other rows were left to grow normally. The first thing to observe was the much deeper green of the cotyledons of the deplumuled plants. This was followed by a remarkable elongation of the petiole and the large size of the obcordate blade, the former attaining a length of three inches and the latter a breadth of an inch and a half. These cotyledons were raised at an angle of about 45°, and the very dark-green blade had a thickness nearly double that of the normal

*Abstract of a paper prepared for the fifth meeting of the Society for Plant Morphology and Physiology, at Columbia University, January 1st, 1902, and published without illustrations in Torrey's February, 1902.

PLATE VIII.

Inbred and Wide-bred Corn. Rows *1*, *2* and *3* are from Inbred grains; rows *4*, *5* and *6* from Wide-bred grains.

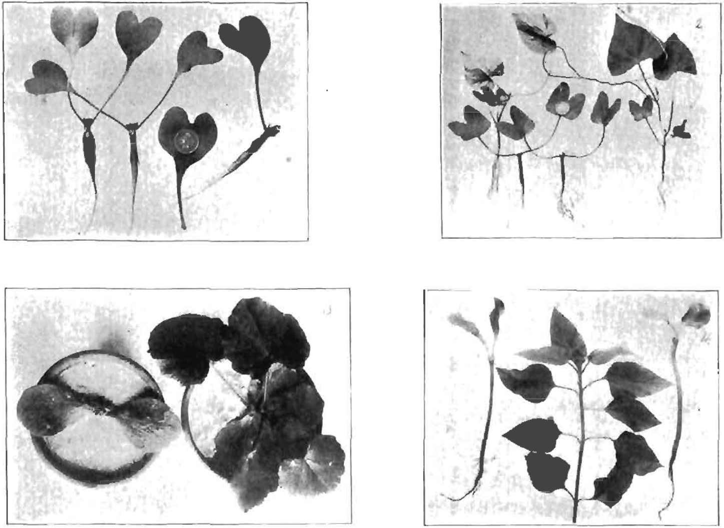

PLATE IX.

Mutilated Seedlings. *1*, Radishes with Bud Removed; *2*, Morning Glories with Bud Removed, one Normal; *3*, Squash Deplumuled *4*, Sunflower Deplumuled, one Normal

cotyledons. A microscopic examination showed that the greater thickness was due to increased size of the cells instead of to a multiplication of the layers. The chlorophyll was excessive and the amount of starch so great as to practically render them black when blanched with alcohol and iodized. The roots grew to nearly market size, and had the tests been made with a turnip-shaped sort instead of a long variety, it is very likely that the roots would have been fit for the table. See 1, Plate IX.

The second species was the common morning-glory (*Ipomœa purpurea*). Here the cotyledons are large in the seedling, but quickly are lost from sight by the development of the much larger alternate true leaves. After holding on for a few days, as a rule, the cotyledons lose their green color and drop from the stem. In the deplumuled seedlings petioles at once begin to elongate, as was shown to be true with the radish, while the remarkable green develops in the blades, that likewise become double or more the normal size and become the organs of photo-synthesis from the mutilated plant. Their dark green is shared by the long, arched petioles (quite different in this respect from those of the radish) and the hypocotyle. The latter becomes of twice the sectional area of the normal plants, that are now several feet high and bearing flowers and become a store-house for the starch, that is robbed of its proper use by the absence of any stem. The root system of the deplumuled plant is not different from that of the normal specimens. See 2, Plate IX.

A third type of plant put to the test is the Hubbard squash, the seedlings of which naturally have large cotyledons. In these the seed leaves remain near the soil, without any apparent elongation of the hypocotyle, but there is a remarkable increase in the size of the cotyledons, until they are sometimes four or more inches in length and very odd, to say the least. Normally, the true leaves come forth from the pumule rapidly, and, due to their large size, the cotyledons are soon out of sight and quickly wither away. Dwarfed squash plants, depending entirely upon the cotyledons, have been kept in apparently healthy condition for four months, the size remaining practically the same after the first four weeks. These plants, unlike those previously mentioned, need frequent attention, for buds will develop in the axils of the seed leaves, which, when removed, will be followed by others without any determined number. If left undisturbed a whole thick cluster of stems and small leaves will develop. See 3, Plate IX.

The eggplant, as representing a slow-growing type of bushy plant, was employed for the tests in question, and it was found that they behaved in a manner similar to the radish, in that the petioles became ridged and nearly upright, and bore the thick, almost fleshy, much-enlarged oblanceolate blades well up in the air and sunshine. In this form the deplumuled plants will stand still, in a very liberal sense of that term, for an indefinite time—not weeks, but long months.

The last type of plant to be considered is represented here by the common sunflower (*Helianthus annuus* L.). As with the other types, the plants in alternate rows were deplumuled. The first change was quickly observed, namely, in the enlargement of the cotyledons, but here the most noticeable thing observed was the elongation of the hypocotyle, which finally reached fully nine inches or double that of the normal plants. There is a greater tendency for pypocotyledonary growth in the sunflower than any other of the types named, and this was remarkably accentuated in the mutilated plant. The structure of this stem, even at the end of three months, retained, generally, the primitive structure it possessed as a young seedling—that is, for example, the wood zone was made of a series of stout bundles, evenly disposed, without the filling in and completion of the thick ring of zylen, so well demonstrated in the normal plant at the same age. See 4, Plate IX.

The experiments illustrate how an organ normally designed to store food for the developing seedling may persist, in case of an emergency, and take on a greatly increased size for that purpose. The petiole may assume a direction in connection to its enlargement that will aid the blade in its work of photo-synthesis. Along with these changes in the seed leaves there may be others in surrounding parts, particularly the hypocotyle when it becomes thickened, remarkably, and green in the morning-glory and greatly elongated, but slender in the sunflower. In case of the radish, a place for any surplus growth is provided for in the root naturally destined to be fleshy, and the hypocotyle is not modified.

Perhaps the greatest surprise is the length of time a plant will hold out when it is deprived of the means for making a successful struggle for life and all possibility of reproduction.

FUNGICIDES AND SPRAYING.

The fungicides employed in the greenhouse during the past season were kerosene emulsion and soap, and, at the Experiment Area, soda-Bordeaux.

The constituents of the emulsion were in the following proportions:

Kerosene	2 pints.
Hard soap	2 ounces.
Water	8 gallons.

This formula is the same as that frequently recommended as a greenhouse insecticide, with the exception that it calls for twice the quantity of water. To prepare, the requisite amount of "Ivory" soap was dissolved in about one gallon of boiling water, and, after removing from the fire, the kerosene was added. Drawing the solutions through a knapsack pump is a very satisfactory method of combining them. Ten minutes "pumping into itself" should produce a creamy mass that will not separate. After adding the proper amount of water the emulsion is ready for use. A considerable quantity of the concentrated emulsion may be set away in closed vessels and drawn out as needed.

The soap solution employed consisted of "Ivory" soap and water in the proportions called for by the emulsion formula, namely, two ounces of soap to eight gallons of water.

How Applied.—For testing different strengths of kerosene emulsion and soap upon a few potted plants, an atomizer was used; but for treating the larger number of plants in the bench, a knapsack pump was employed after the first two weeks. The atomizer is very convenient where only a pint or two is to be applied, but for larger amounts the knapsack pump is much more satisfactory, it applying the solution more thoroughly and in a much shorter time.

A—*In the Greenhouse.*—For testing the fungicidal values of kerosene emulsion and soap in the Station greenhouse, mildewed plants of *Phlox Drummondii* and the common verbena were employed. On November 8th mildewed seedlings of these were selected and transferred from the Experiment Area to the coolest benches in the greenhouse. They were disposed in twenty-one cross-rows, five plants to a row.

The disease thrived under the new conditions, and by the end of two weeks its presence upon the plants was very apparent. Spraying

was begun November 27th, and between that date and April 1st twenty-six applications were made. During cloudy weather, when the conditions were most favorable to the mildew, the applications were made every two days.

For a time there was no striking contrast between the sprayed plants and the unsprayed; but after the third week the mildew was much more conspicuous upon the unsprayed. These made but feeble growth and developed almost no flowers. Before the end of the season two-thirds of the phlox plants were dead. The check verbenas survived, but were practically worthless.

The plants treated with kerosene emulsion, although not wholly free from mildew, were not sufficiently affected to prevent their making a vigorous growth, and in due time blooming freely until the end of the season. Plate X. shows a portion of the spraying experiment with phlox. The untreated rows are upon the right and treated rows upon the left.

About midwinter a verbena plant seriously affected by mildew was transplanted to a box and its foliage divided as nearly as possible by a board partition. One of these halves was sprayed every six days with kerosene emulsion, while the other was untreated. The appearance of the plant at the end of the season is shown in Plate XI.

The soap solution was applied throughout the season at the same intervals as the emulsion, and while its effect upon the mildew was apparent, the plants so treated were plainly inferior to those sprayed with emulsion.

A limited test was made of the fungicidal value of half and quarter-strength solutions of the greenhouse fungicides employed.

3	potted	plants	were	sprayed	with	half-strength	kerosene	emulsion.
3	"	"	"	"	"	quarter "	"	"
3	"	"	"	"	"	half "	"	soap.
3	"	"	"	"	"	quarter "	"	"

These plants were sprayed at the same intervals as those in the bench. The half and quarter-strength emulsion seemed to prevent the mildew about as well as the full-strength solution, but it is desired to make a more extended trial of the weaker solutions before advising their use.

Half and quarter-strength soaps checked the mildew but little; the plants so treated being severely infested.

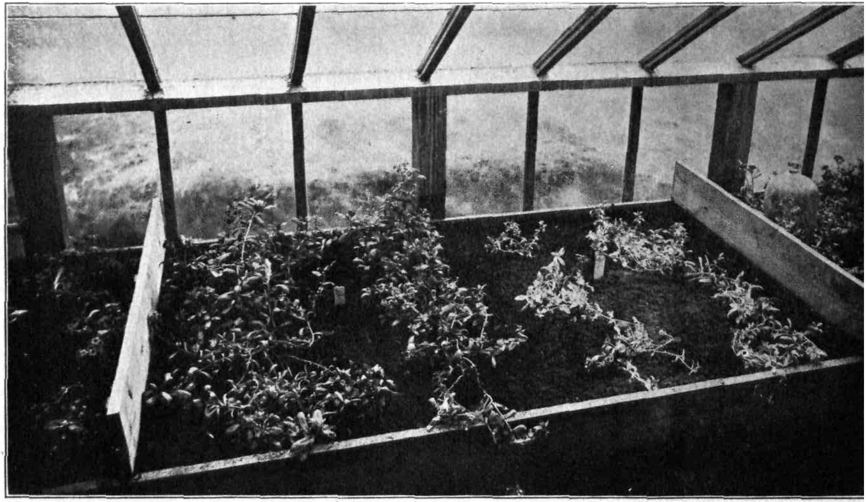

PLATE X

A portion of *the Phlox bed showing the rows of* Untreated Plants *on* the *right*, and the two Sprayed rows upon the left.

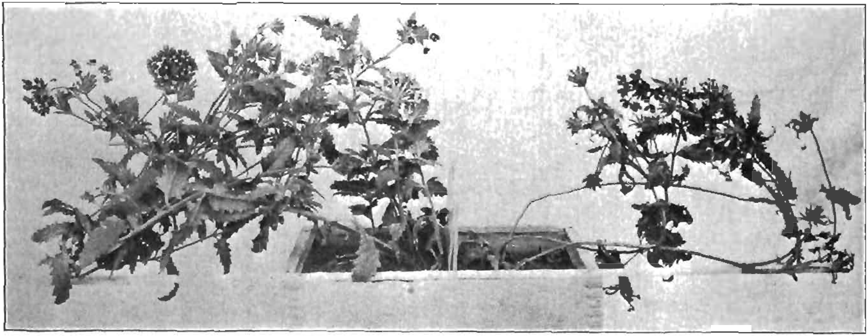

PLATE XI.

A Verbena Plant one-half (right) of which was left Unsprayed, while the other was treated with Kerosene *Emulsion*.

B—*In the Field.*—There was practically no spraying during the past summer at the Experiment Area. It was intended to spray with soda-Bordeaux two belts of bush beans, one belt of stock tomatoes, one belt of watermelons and all the crossed cucumbers.

The first application was made July 12th, the second July 23d, after which it seemed almost impossible to repeat the applications as frequently as conditions demanded without neglecting other duties. Spraying was therefore discontinued. No appreciable results followed the two applications.

FUNGI AS RELATED TO WEATHER.

The following items are gathered from the "Weather and Crop Bulletins" issued weekly by the State Weather Service during the months of April to September:

July 8th—"Tomatoes backward and showing some blight;" "Plums rotting;" "Apples dropping."

July 15th—"Blight or fungus has appeared on the apple trees, leaves becoming yellow and spotted;" "Tomatoes and potatoes blighting."

July 22d—"Less injury by insects and fungus."

July 29th—"Plums rotting on the trees."

August 5th—"Potatoes blighting and much affected by scab;" "Potatoes being blighted;" "Potato vines turning yellow and some rot showing;" "Plums rotting somewhat;" "Some blight appeared in tomatoes;" "Potato rot feared if present showery conditions continue;" "Asparagus rust spreading rapidly, both on old and new beds;" "Potatoes on low ground rotting;" "Apples dropping badly;" "Grapes doing well, very little rot;" "Sweet potatoes making too much vine;" "Potatoes a heavy crop, but rotting badly; "Grapes doing well, no rot;" "White potatoes rotting in low fields."

August 12th—"Early potatoes being dug, some fields badly rotted;" "A large crop of potatoes is being dug, some rot showing;" "Potatoes show indications of rot on wet land;" "Many tomato fields are affected by blight;" "Some potatoes rotting in low ground;" "Cantaloupes poor, vines scalding;" "Plums rotting on the trees."

August 19th—"Muskmelon vines have commenced to blight;" "Plums and peaches both rotting;" "Only one case of rot in potatoes heard from, and that is in low, damp ground;" "Some rot in potatoes on wet ground;" "Potatoes show signs of rot;" "Some peaches rotted;"

"Asparagus rusting;" "Late tomatoes blighting;" "Many peaches have rotted on the trees;" "Peaches a light crop, early varieties cracking and rotting owing to excessive rains;" "Peaches, good crop, but frequent rains have caused much rotting;" "Corn in low fields scalding;" "White potatoes rotting in low fields."

August 26th—"Some potato rot;" "Potato crop heaviest in several years, but rotting in low ground;" "Peaches and plums rotting on the trees;" "Grapes out of danger from rot."

September 2d—"Potatoes rotting in places;" "Potatoes a large yield, but rotting;" "About one-third of the potatoes have rotted."

September 9th—"Potatoes in many places are rotting badly;" "Heaviest and finest yield of potatoes for years, no rot;" "Tomato blight severe, fruit dropping from the vines."

September 16th—"Potatoes all dug, some rot."

Temperature and Rainfall Since 1889.

The following table shows the temperature, in degrees (F.), and rainfall, in inches, for the present year, and the average for the past thirteen years since the Station was established:

	Temperature.		Rainfall.	
Month.	1902.	Average 13 years.	1902.	Average 13 years.
January	28.4	29.9	3.28	3.66
February	27.4	31.4	6.24	4.05
March	43.9	38.4	4.34	3.89
April	50.2	49.1	3.62	3.42
May	60.3	60.6	2.04	4.50
June	67.5	69.7	6.57	3.54
July	73.0	74.0	4.78	4.96
August	70.1	72.5	3.91	4.21
September	64.6	66.3	5.65	3.68
October	56.0	53.9	6.39	3.68
November	49.3	43.5	2.20	3.99
December	31.7	34.3	7.23	3.39

In temperature, 1902 had a cold January and February, with a warm March, April and May, an average and cool June and August, with July somewhat below the normal. There was an excess of moisture in February and June, with a small rainfall in May and less than the average in July and August.

NOTES UPON SOME RUSTS AND MILDEWS AT WERNERSVILLE, PA.

While sojourning for health at Wernersville, Pennsylvania, during several weeks in the spring, some observations were made upon the parasitic fungi of that region.

Rusts.—Among the first of the rusts to appear was an *Aecidium* upon *Ranunculus abortivus*. This host is very common in the open woods, and the rusted plant is easily detected by the small, spade-shaped leaves, that stand up edgewise upon long, slender petioles. The diseased plants last for only a week or so after the cluster cups appear, thickly covering the under side of each leaf. The fungus seems to destroy all the portion of the plant above ground, and while, during one week, the display of rust is extensive, at the end of the next there is little left excepting dead leaves.

There were some small quince orchards in the region, and one in particular was bordered upon two sides by a hillside covered with cedar trees. In some instances the branches of the quince trees and those of the cedars interlocked. The cedars bore an abundance of the large, yellow galls commonly known as "cedar apples." These are the conspicuous formations of the rust fungus known as *Gymnosporangium macropus,* and in another form does much damage to the apple leaves and fruit. Upon the same cedar trees was an abundance of another species of *Gymosporangium* (*G. globosum*). This does not produce spherical galls like the one first mentioned, but causes a swelling of the small branches until they are somewhat spindle-formed, and become covered with an orange coating at the time when spores are set free. Upon the quince leaves, before they were full-sized, the rust appeared in considerable quantity, sometimes occupying all of the under surface when the numerous clusters of deep cups were produced. Later on the fruits probably became infested, for the mummy fruit of the previous year showed that the fungus had destroyed them. This *Roestelia aurantiaca,* as the orange rust of the quince is sometimes called, botanically, might be reduced by separating the two host plants of the fungus by cutting away the cedars near the orchards or exercising care in setting quince trees apart from the cedars.

The ash trees showed conspicuously the rust (*Aecidium Fraxini*) that is common to the species of *Fraxinus*. In the present instance some ash trees were entirely free, while others of the same species had

their leaves badly infested. This fungus works upon the leaf stalk in particular and causes it to twist into all sorts of fantastic shapes.

Wild roses, in some places, were so badly infested with a rust (*Phragmidium subcorticum*) that they were practically destroyed. This fungus, of an orange color, attacks the canes, as well as the leaves, and distorts and dwarfs them. This fungus was found in patches upon the untilled hillsides, while in other places the rose-bushes were free from it and healthy.

Among the herbs infested with a rust may be mentioned the sweet cicely (*Osmorrhiza brevistyles*), which is usually more or less affected with the *Puccinia Pimpinillæ* Strauss.

Mildews.—The *Peronospora Ficariæ* Tul., upon *Ranunculus recurvatus*, was quite abundant early in the season. Other hosts for same mildew were *Ranunculus abortivus* and *R. repens*, but it was most conspicuous upon the first-named crowfoot.

A chickweed (*Cerastium longipedunculatum*) was abundant in that region and badly infested with *Peronospora alsinearum* Casp. The mildewed plant usually remained small and produced no flowers. In some patches all the plants were diseased and dwarfed.

The tall figwort (*Scrophularia Marylandica* L.) showed the most conspicuous mildew, its large leaves being much discolored and sometimes distorted by the *Peronospora sordida* Berk. This is one of the mildews that produces a decidedly violet coating upon the infested part of the leaf, and, also, the border of the mildewed spot has a distinct purple border, as seen from the upper side. Some of the young plants were so badly infested as to be ruined.

The galiums were badly mildewed with *Peronospora calotheca* DeBy. It was most common upon the upright *Galium* Sp., where the whole plant was dwarfed and rendered of a pale color.

Many other fungi were met with, of which only one may be added here, namely, a smut upon Actea or Baneberry. This *Urocystis* infests the whole plant, from the base of the stem to the divisions of the large, compound leaf.

A large number of specimens of these various parasite fungi were secured for further study and distribution.

FUNGOUS ENEMIES OF PLANTS IN NOVA SCOTIA.

A trip was made into Nova Scotia for personal health. Five places were visited, namely, Halifax, Wolfville, Kentville, Digby and Yarmouth. Wolfville and Kentville are in the region of extensive fruit-growing, and particularly the orchard, crops. This is the home of the Gravenstein apple. Plums are grown quite extensively.

The following are some notes made upon the prevailing fungi infesting crop plants:

Apple—
Anthracnose of fruit or ripe rot (*Glœosporium fructigenum* Berk.).
Scab (*Fusicladium dendriticum* (Wallr.) Fckl = *Venturia inæqualis* (Cke) Ad.).

Barley—
Smut (*Ustilago Hordei* (P.) Kell. & Sw., and *U. nuda* (Jens.) Kell & Sw.).

Bean—
Anthracnose (*Colletotrichum Lindemuthianum* (Sacc & Magn.) Bri & Cav.).

Beet—
Leaf-Blight (*Cercospora beticola* Sacc.).

Backberry—
Leaf-Spot (*Septoria Rubi* Westd.).
Rust (*Cæoma* (*Uredo*) *luminatum* Lk.; Syn. *Puccinia Peckiana* Hwe).

Catalpa—
Leaf-Spot (*Phyllosticta Catalpæ* Ell. & Mart.).

Cherry—
Black Knot (*Plowrightia morbosa* (Schw.) Sacc.).
Fruit-Mold (*Sclerotinia cinerea* (Bon.) Schrt.).
Leaf-Spot (*Cylindrosporium Padi* Karst. = *Septoria cerasina* Pk.).

Clover—
Leaf-Spot (*Phyllachora Trifolii* (P.) Fckl.).
Rust (*Uromyces Trifolii* (A. & S.) Wint.).

Currant—
Anthracnose (*Glæosporium Ribis* (Lib.) Mont. & Desm.).

Hollyhock—
Rust (*Puccinia Malvacearum* Mont).

Horse-Chestnut—
Leaf-Spot (*Phyllosticta sphæropsoidea* Ell. & Ev.).

Maple—
Leaf-Spot (*Phyllosticta acericola* Cke. & Ell.).

Oats—
Rust (*Puccinia coronata* Cda, and *P. Graminis* P.).
Smut (*Ustilago Avenæ* (P.) Jens, and *U. Levis* Kell. & Sw.) Magn).

Peach—
Leaf-Blight or Shot-hole (*Cercospora Persica* Sacc).
Leaf-Curl (*Exoascus deformans* (Berk) Fckl.).
Scab (*Cladosporium carpophilum* Thum.).

Plum—
Black Knot (*Plowrightia morbosa* (Schw.) Sacc)

Potato—
Leaf Mold or Early Blight (*Alternaria Solani* (E. & M.) Jones & Grout).
Scab (*Oospora scabies* Thaxter).

Quince—
Rust (*Gymnosporangium* sp., Syn. *Ræstelia* sp).

Rose—
Rust (*Phragmidium subcorticium* (Schrank) Wint., and *Ph. speciosum* Fr.).

Rye—
Smut (*Urocystis occulta* (Wallr) Rabh.).

Strawberry—
Leaf-Spot (*Sphærella Fragariæ* (Tul.) Sacc.).

Tomato—
Leaf-Spot (*Septoria* sp.).

Violet—
Leaf-Blight (*Cercospora Violæ* Sacc.).

Many specimens of nearly all the above species of economic fungi were collected, together with a large number of those upon weeds and wild plants. After further study these will be ready for distribution among the various centres of mycological investigation.

REPORT OF ENTOMOLOGIST.

Somewhat later the insects became more plentiful, and some of the latest canning varieties were dwarfed. There was no complaint of late summer planting, and, altogether, practically no injury was caused. It would be unsafe to say that this marks the disappearance of the pest or even the beginning of the end. Conditions controlling abnormal insect increase are so little understood that we can make predictions only when a number of outbreaks have occurred.

Clover Lice became troublesome twice, as reported in the Crop Bulletin; but, unfortunately, no specimens were sent me, and I had no opportunity for determining what species caused the difficulty. As the pea louse lives on clover as an alternate food-plant, the possibility exists that this was a summer occurrence of that species.

Tomato Lice became noticeably abundant early in July, and for a week or two almost every mail brought in letters from Burlington, Camden, Gloucester or Mercer county, describing the infestation and demanding instant relief measures. A sample letter reads: "Please advise at once what to do for tomato lice. Have three acres which will be ruined unless given prompt attention." An even more urgent grower telegraphed his inquiry and asked a telegraphic response. One of the Commissioners wrote: "Our farmers have about 100 acres out in tomatoes and say these lice are killing them. Tell us what to do."

Whale-oil soap was recommended in each case; but as it is no unusual thing for this particular aphid to become rather plentiful in July, I suggested that no treatment be made unless immediate injury threatened. The fact that numerous Coccinellid larvæ and other parasites came in with every sending, made me feel safe in advising a waiting policy.

As I expected, it happened—the early crop was considerably injured; but, beginning about the middle of the month, the insects began to disappear. A letter, dated July 14th, reads: "I gave the whale-oil soap a trial and it killed the lice very successfully and did no apparent harm to the tomato. I did not go far with the soap, for I found the louse was leaving the tomato. I am satisfied, had I put the soap on a week sooner, I would have had much better vines now."

The reports were not confined to the counties already mentioned, but reached north as far as Hunterdon. The discouraging feature was that, while asking for a remedy, one grower stated that he had already applied Paris green, and another confessed to a failure from

a mixture of Paris green, wood ashes and plaster. The fact that stomach poisons can never prove effectual against plant lice seems to take a long while and many repetitions to become generally known.

Potato Lice appeared in some numbers near Moorestown about the middle of June and for a time threatened injury, but, as with the tomato lice, the threat was short lived—the insects disappeared and the plants recovered.

Apple Lice became locally plentiful in July, but no real injury was noted. There was a very general spread, however, until, in early October, sexed individuals occurred everywhere. In late October eggs were plentiful on susceptible varieties and there is promise for a heavy spring infestation at the date of present writing. Yet, an unfavorable turn of weather at just the right time next April may clear out almost the entire brood and leave the trees free for the season.

Melon Lice were observed in some numbers in Gloucester county in June, and for a little time the indications were for a disastrous season. But conditions changed, and, except on a few fields, no harm was done.

Strawberry Lice were kept in mind when examining beds from which plants were to be sold; but very little infestation was noted. These insects are serious pests in some more southern States, and strawberry plants are liable to inspection if introduced into them from New Jersey. I have therefore advised our growers to fumigate their plants in proper boxes before shipping them.

Peach Root Lice were credited with destroying a large number of young trees in Atlantic county and seriously retarding others. It is quite probable, from what I have observed, that this pest is much more common and widespread than growers appreciate. This is one of the pests on nursery stock that will be destroyed by fumigation, and that practice will tend to check their spread into new areas. Good feeding, to stimulate growth during the first two or three years, will give a large, healthy root system, capable of resisting ordinary attacks by these insects.

Lice on lima beans were several times reported, and, apparently, some local injury was caused.

The *Corn Root Louse* was obvious enough to cause visible injury, and I have reason to believe it did much mischief attributed to other causes. Some other species were referred to in the correspondence, but seem to have been of local importance only.

Altogether, this past summer was unfavorable to plant lice and correspondingly advantageous to the farmer. No widespread damage was caused on any crop except tomato, and there it was not serious. *So far as remedial measures were employed, whale-oil soap proved itself* most satisfactory, but it may be worth repeating that neither Paris green nor any other of the forms of arsenic is of the least use against plant lice of any kind.

Fall Web-Worm.

In recording the unusual abundance of this insect in 1901, I ventured the prediction that in 1902 it would, in all probability, be much less numerous and troublesome. This prediction was based, in part, upon observations indicating an increase in the natural enemies, and, in part, upon past experience with this same species.

The event justified the prophecy; but there was a period early in the year when it seemed likely to prove false. The early brood, in fact, was unusually abundant, and, in driving through the orchard districts of Monmouth, Mercer and Middlesex, in June, every plantation showed trees with webs; in some, indeed, almost every tree had at least one brood. So numerous did these nests become, and so generally distributed were they, that I deemed it wise to call attention to the matter in the Crop Bulletin, recommending energetic action to destroy them.

But before the larvæ were full grown they began to die off and few of them ever reached the pupal stage. Moths from this brood of caterpillars were very scarce, and, after midsummer, scarcely a web or nest was to be seen. The fall web-worm has been put back by nature's own methods into a position that will make injury from it unlikely for at least two or three years to come. This effect was not local or in any way confined to restricted areas—it was universal and effective—amounting to practical annihilation for millions of caterpillars within a few days.

The Vaporer Moth.

The experience with this species was somewhat different from that with the fall web-worm, because this form made practically no show at all early in the season. Of the myriads of larvæ that spun up during the fall of 1901, comparatively few matured; yet enough to produce egg masses in great number. But the eggs did not hatch, or

the young larvæ died; in any case, what remained did no appreciable injury and attracted no attention. The second brood was much more in evidence, and, locally, even abundant, so that there is a possibility that, during the summer of 1903, the species may become as troublesome as it is in ordinary years.

Orchard Insects.

Quite a marked feature was the comparatively small number of codling moth and plum curculio in the orchards at large. There were localities where the curculio was as bad as it could well be, but these were rather exceptional. So, wormy apples were scarce, even where no spraying was done, and there was an unusual proportion of fair fruit everywhere. But the insects were by no means absent, and there is danger that, should next year's crop be in any way shortened, the insects will be found sufficient to annex it. The careful fruit grower will be especially thorough in his spraying work next spring, while the careless grower will, banking on his escape this season, trust to luck once more, and probably lose by it.

Other orchard insects were also rare, and fruit growers had, on the whole, as favorable a season as could well be wished for.

Strawberry Weevil.

A few complaints were received of injury to strawberries in Burlington county, in which this insect was recognized as the author; but many more were made in such terms as to show that the fruit grower had failed to recognize his enemy. From such information as I was able to gain, it is probable that, locally, the crop was reduced by fully one-half. Areas of injury extended into Burlington and Cumberland counties and probably other localities were more or less affected, though not reported.

It is well that this insect does not often become very abundant, because its habits are such that we cannot reach it with insecticides.

Rose-Bugs.

These insects continue to increase in certain parts of the State and do considerable damage to fruits and flowers. They seem to be preparing for another period of abundance, such as was in progress in

1890 and 1891, but have not yet reached anything like that stage. Nothing has been added to our batteries that enables us to kill the insect any more rapidly than we could in the past, and collecting in kerosene pans is yet the most reliable method of doing away with it.

Vineyards have not yet been attacked to any extent, but in gardens, grapes have, in some places, suffered severely. In such cases bagging may be resorted to with satisfactory results, and, where only a few fruit trees are to be protected, the Bordeaux mixture is of considerable advantage. Paris green acts slowly, and, while it kills the beetles in time, does not prevent injury.

Grain Insects.

Grain farmers have suffered severely for some years past, less from the Hessian fly, perhaps, than from the Angoumois grain moth; the former being more troublesome in the northern parts of the State, the latter destructive to the south. In each section practice is adapting itself to conditions—late seeding in the north—early threshing in the south. This year the early cold snap induced dangerously early seeding in many places, and it would not be a matter for surprise if the summer of 1903 developed more injury from Hessian fly in North Jersey than for the two or three years last past. Normal seeding time in South Jersey is usually late enough to avoid injury.

Rose Scale.

This insect has been under observation for some years, but it had not been classed among the positively injurious species until within the year or two last past, when it became troublesome on blackberry and raspberry bushes. The material accumulated from previous observations was supplemented by a series of experiments and studies made by Mr. Henry Pfeiffer, of Cologne, and Mr. E. L. Dickerson, under my direction. The results were embodied in Bulletin No. 159, which was sent out in July.

That it was timely was indicated by several communications; notably one from Elmer, in August, in which it was stated that "your remedy for the rose scale was tried and proved very successful."

Periodical Cicada.

The occurrence of Brood XXII. of the periodical cicada during the early summer made it possible to study its distribution more carefully than had been previously done. All of the broods scheduled to appear in New Jersey have now occurred since my connection with the Station, and this is, therefore, a good time to present a general review of the observations made on them and a map illustrating their general distribution. All this is given on a later page, without any attempt at a complete life history, which has been given in previous reports and bulletins.

Oak Pruner.

An unusual number of dying twigs in oak woods and on isolated trees was noticed during the late summer and a few inquiries were received. In looking out for signs of cicada, these dying twigs were sometimes so plentiful as to raise a momentary doubt concerning the cause.

The oak pruner is a round-headed borer that lives in the small branches or larger twigs of oak trees. When it becomes nearly grown it eats from the inside until the wood is cut almost through, and the first high wind will cause the girdled shoot to break and fall. The larvæ remain in the cut end and fall to the ground, completing their transformations in the dry stick. In the forest the injury amounts to a harmless pruning only; on shade trees the injury is more marked, and the fallen twigs and branches should be gathered and burnt to prevent the larvæ contained in them from coming to maturity.

IMPORTED MANTIDS.

In the report for 1901 I stated what had been done in the way of distributing egg masses of the European praying mantids and the allied Chinese species. As the character of the insects and the object of bringing them into New Jersey were there explained, nothing need now be said on these points. Except at New Brunswick, no insects were found as the result of the settings out. At Burlington I had a chance to look over the area in which the egg masses had been distributed the year before and no traces of the species were observed. At New Brunswick I found several egg masses of the Chinese species

during the winter of 1901–1902 within 500 feet of the point where I set out the cases in the spring of 1901. It was proved, therefore, that the insects could live over at this point.

In April, 1902, I received another lot of egg masses of the European species from Professor M. V. Slingerland, collected in Northern New York, and a fine lot of cases of the Chinese species, taken near Philadelphia by Mr. Philip Laurent.

The eggs of the European species were divided between Mr. H. W. Collingwood, editor of the *Rural New Yorker*, who tied them out on low shrubs at Woodcliff, N. J.; Mr. Hiram T. Jones, who put them out near Elizabeth, and Mr. E. L. Dickerson, who placed them near Newark and near Arlington.

Nothing was seen of any adults from any of these plantings. Mr. Collingwood reported having made an examination, finding no signs of hatching, while some cases had been picked open—perhaps by birds. Mr. Dickerson went over the ground stocked by him in the early fall of 1902, but found no trace whatever of insects. Egg masses were found yet tied in place and from these the insects seemed to have emerged in part.

The egg masses of the Chinese species were divided between Mr. Charles Black, at Hightstown, Mr. Charles B. Horner, of Mount Holly, and Mr. E. L. Dickerson. Mr. Black and Mr. Horner each placed the eggs on their respective farms, and Mr. Dickerson divided his between the vicinity of Newark and the vicinity of Arlington, in territory adjacent to that in which the European species had been distributed. From all of these plantings adults were reported, directly or indirectly. Messrs. Horner and Black both sent me examples of the adults, absolutely proving their occurrence, while the Arlington specimens were reported by Mr. Wm. Beutenmuller, of the American Museum of Natural History.

In early October several specimens, male and female, were noted in the Experiment Orchard at New Brunswick, but there seems to have been no disposition to spread to other places.

Mr. L. H. Joutel, of New York City, informs me that he put out several egg masses of the Chinese species near Fort Lee, and that some of these hatched.

The insects have now a fair chance for life in several localities, and, if they will do well with us, should be found in some numbers next year.

Grape Insects.

The Grape leaf-hoppers have been unusually abundant this year, and, in some places, have very materially affected the crop. Almost everywhere they have browned and dried the foliage, causing it to drop much sooner than it would otherwise have done. In New York State the matter was much worse, as I am informed by Professor Slingerland, of the Cornell Experiment Station, and the crop there was very seriously shortened. The life history of the insects and the best method of dealing with them will be published by the New York Station.

Another grape insect came to hand late in 1901, but was not identified in time to be referred to in the report for that year. It is a leaf-roller, from the Egg Harbor district, where it was said to do considerable damage. The larvæ that were sent me pupated and developed adults in the spring of 1902. They proved to be *Desmia funeralis* Hbn., a species which is rather common throughout the State, but has not been troublesome before in my experience. It is not likely to become more plentiful or more than locally injurious.

Elm Leaf Beetle.

This insect has been more abundant during 1902 than for several years past, and has disfigured trees in cities and towns that had been little troubled of late. At New Brunswick the heavy sleet storm of February, 1902, broke so many branches of the larger elms that they were badly mutilated to begin with. The foliage was irregular and scant in consequence, and the beetles were much more concentrated upon it than would have been the case under normal conditions. Injury was therefore more obvious than usual, in spite of the sprayings that were made.

At Newark and in its vicinity the pupæ were attacked by a fungus disease similar to that which attacked the insects in the same stage at New Brunswick in 1896. So general was this infection that the indications are for a very light brood at Newark for 1903. At New Brunswick the disease was not observed.

Cabbage Insects.

Cabbage-worms have not been nearly as abundant as usual and I have seen very little signs of damage anywhere. But the beautifully striped and banded larva of *Mamestra picta*, which belongs rather to the cut-worm tribe, was more common than it is ordinarily. It was not confined to cabbage, but was sent in from a great variety of plants. Cauliflower was among those attacked, and one of my correspondents said that, while they occurred in patches only, the plants were literally covered. The feeding in colonies is rather a habit of this species; those hatched from the same batch of eggs remaining together until they are nearly full grown. For remedial measures, the arsenites answer every purpose, and the resin-lime mixture is, on the whole, the best of them.

An insect very rare as an injurious form in New Jersey is the cabbage weevil; but this made its appearance near Moorestown in numbers sufficient to attract attention. According to my correspondent, "they seem to eat in the heart and inside leaves, doing some damage, but not much as yet." Fortunately they did not increase, and the question of remedial measures did not arise.

Sometimes it happens that an insect primarily injurious to a field crop modifies its habits so as to enable it to attack one grown under glass. Of this type is the little "diamond back moth," *Plutella cruciferarum*. Its natural food plant is cabbage, but it has adopted the "wall flower," which belongs to the same natural family, as an alternate, and becomes troublesome in greenhouses in which these plants are grown. In the fields little is seen of the insect, and during the winter it is not very active; but when the sun gets higher, in spring, it multiplies and injury becomes serious. The free use of pyrethrum seems to have proved the most effective method to keep this pest in check under glass; in the garden or field I have seen no case that required serious attention.

San Jose Scale.

Nothing was added to our knowledge of the habits or life history of the pernicious scale from this department. Most of the work done with or because of it was in my capacity as State Entomologist, and only the matter of insecticides for its destruction received especial attention. There may be found, even yet, fruit growers who are con-

vinced that the injurious character of the insect has been unduly magnified and who will not be persuaded to attend to their infested trees. But they are now in the small minority, and experience has shown that it is better to allow such men to go their own way, since the life of infested trees is very short and their death removes the source of spread. With the general recognition of the danger from the insect, with the adoption of the remedial measures now at hand, and with care exercised in the distribution of nursery stock, we may fairly say that we are at the beginning of the end of the scale dominion.

Chinese Lady-Birds.

In the fight against injurious insects the matter of natural enemies has of late years assumed an important place. When the insect to be dealt with is a native species we are practically helpless, for nature itself has in that case established a balance which is not easily changed. Where the injurious species comes from some other country the matter is different, and it is always important to know whether in its natural home the insect is as troublesome as it is in its new domain. If it is not, we are put upon inquiry to ascertain why this difference exists, and, if the check in the old home is some parasitic or predatory form, whether we cannot bring this to our aid.

So, the question of a natural enemy to the San Jose scale has been before us for years, and, in my previous reports, this point has been more than once touched upon. A special trip to California on this behalf proved fruitless; but not without benefit in the matter of information obtained.

The main trouble was that we did not really know where the pernicious scale actually was at home and our experiments were, of necessity, somewhat haphazard. During the summer of 1901 Mr. C. L. Marlatt, of the Division of Entomology of the United States Department of Agriculture, spent some time in China and Japan and discovered that, without reasonable doubt, northern China is the native home of the insect and that it is there kept in check by a beetle of the Coccinellid or lady-bird family. Some of these beetles were sent to Washington and enough of them survived to start breeding in the spring of 1902.

By the courtesy of the Department some of the insects were sent to me and were placed in cages covering scale-infested trees. Details of this experiment are given in another part of the Report.

Crude Petroleum.

No specific experiments were made with this material. Its range and the method of its application have been again and again repeated, and, despite some bad results, its use has been steadily extended. It has been found that while it may not be always safe when applied in one way, it may be used in another with excellent effect. The material is now really in the hands of the fruit growers and their experience must decide its range and usefulness. Its value, as compared with the lime, salt and sulphur wash remains to be fixed, and it will be found, I think, to have a field that the other cannot fill. Tests have now been made in many localities, and, while it is rarely recommended for use undiluted, the mechanical mixtures or emulsions are ever more effectively employed. On another page this subject is again referred to, somewhat more at length.

The Lime, Salt and Sulphur Wash.

In the records of the Experiment Orchard there will be found a number of references to sprayings made with "Calcothion," which is in effect a ready-made lime, salt and sulphur wash, in condition to apply without further preparation. It was used to determine, in part, whether it was really good for anything and, in part, assuming its composition to be practically the same as that prepared by the farmer from the ordinary formula, whether the application made cold would give the same results as when applied hot.

The recommendation to "apply hot" is not so easy a one to follow, for, even if your mixture is so hot as to require a guard to enable one to hold the spray rod comfortably, yet, by the time it gets through the nozzle as a spray, to the branches of a tree only ten feet away, there is very little heat left in the particles. If the outside temperature at all approaches the freezing point, a temperature over 70° will be practically impossible. Through a Vermorel nozzle the material is forced in particles so small that three feet away boiled water is reduced to the temperature of the air. On this point I speak from experience gained in a series of tests made with hot water as an insecticide for rose-chafers.

If high temperature at the point of contact is, therefore, essential to the action of the insecticide, much imperfect work must result and the effectiveness of the wash must decrease as the point to be reached

becomes more distant from the nozzle. Trees thirty feet high, and as much in diameter, which is not unusual for old apples, could never be covered, from any ordinary spray nozzle, with "hot" material. Nor could spraying be done on even much smaller trees on very cold days or when there was any wind at all, for this would absorb heat too fast.

Practically, the Calcothion,* applied cold, was quite as effective as any lime, salt and sulphur application made anywhere in New Jersey. For details, the record of the Experiment Orchard should be referred to; but, roughly stated, all the areas to which it was applied were cleared of scale and remained clean until late in the season. It adhered much better than whitewash and could be readily noticed two months after the application. The material was received too late to be applied to entire trees without serious injury. They were already in practically full foliage and the experience was that every leaf wet with the mixture was killed. On peach, the entire shoots were killed, and, in some cases, no further growth was made from these points. Hence, no tree was entirely cleared of scale by the mixture, and areas clean in midsummer showed re-infestation in fall.

While testing the "Calcothion," a number of other trees were treated with lime and salt only—really an ordinary whitewash, with considerable salt added to increase its sticking qualities. This was applied with a brush to the trunk and branches to determine its lasting qualities and, incidentally, its effect upon the scales. It proved much less resistant to the weather, and the coating quickly became imperfect.

On smooth trees, especially, its life was short; but on rough, scarred bark it remained noticeable until midsummer. No great effect was produced upon the scales, but the coated areas were avoided by the larvæ. On the rough-barked trunks very few insects set; but this was probably as much due to the mechanical condition of the bark as anything else.

Bulletin No. 162 was prepared at the end of the season to summarize the results obtained and to serve as a guide to fruit growers for winter applications. The matter presented in that Bulletin need not be repeated here; it is sufficient to say that information gathered from all sources, within and without the State, indicates that the lime, salt and sulphur wash, properly prepared and properly applied, is an effective destroyer of the pernicious scale and is more safely applied to sensitive trees, like peach, than the mineral oils.

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*Adler Color and Chemical Co., 100 William street, New York City, N. Y.

The formula most generally used in New Jersey is:

Flowers of Sulphur	50 pounds.
Stone Lime	50 "
Stock Salt	50 "
Water	150 gallons.

Slake the lime with hot water, add the sulphur and boil for at least an hour, adding water, from time to time, as needed to keep the mixture sufficiently fluid. Then add the salt, and, when that is dissolved, boil for at least fifteen minutes more, adding hot water to make up the 150 gallons. The product, if the boiling is thoroughly done, is a double sulphide of lime, is very caustic and should be strained before using.

Shell lime may be used instead of stone, if more convenient, and the amount of salt may be somewhat reduced without harm. The formula, as it stands, is easily remembered, since it only requires equal parts of lime, salt and sulphur, no matter what quantity is used, and the amount of water is always three times as many gallons as there are pounds of sulphur.

The salt may be replaced by blue vitriol, four and one-sixth pounds of the crystals equaling the fifty pounds of salt. The cost is about the same and the mixture is said to be rather more quickly effective. If the blue vitriol is to be used, the crystals should be dissolved in water and the solution added slowly to the boiling mass of lime and sulphur.

The wash may be applied through any apparatus that will properly spray the Bordeaux mixture and must be thoroughly applied to be effective. Its corrosive character has been already referred to, and pumps, nozzles and other machinery should be thoroughly washed and oiled after using it.

In the peach orchard this material is much safer than crude petroleum and will probably replace it. I doubt whether it equals the oil for other trees, and it cannot entirely replace that product where bad infestations are to be dealt with. In the year's experience in Georgia, this wash stands third, with crude oil in emulsion or mechanical mixtures in the lead.

Thorough application of the sulphur wash must be insisted on, since it kills only what it hits and does not spread like oil or soap solutions. The cost of the wash for materials alone, irrespective of

fuel or the labor of preparing it, is between one and one-half and two cents per gallon.

For other details, Bulletin No. 162 should be consulted.

Other Insecticide Tests.

Almost each year samples of insecticides are sent in to be tested; sometimes evidently for advertising purposes, sometimes by makers who are really trying to get up a meritorious mixture for a specific purpose. It is not always possible to make these experiments under satisfactory conditions, and some of the substances are obviously out of court owing to the price demanded. Where a responsible firm attempts to make a standard mixture it does not hesitate to give the character of the materials used and the other facts necessary for an intelligent test of its insecticide value, and for them I make such tests whenever possible.

Three mixtures only were tried this past season—"Caleothion," "Agricultural Soap" and "Black Soluble Insecticide Soap." The first and second were experimental preparations sent in to be tested before being regularly placed upon the market. The third was already on the market and was supposed to be a "gold medal" substance, greatly the superior of anything heretofore known.

All of these were tried in the Experiment Orchard, and the record given on another page should be referred to for the results obtained.

Fumigation.

This subject is becoming of ever greater importance to the nurseryman, as the spread of the pernicious scale demands ever greater care on his part in selecting the stock to be sent out to purchasers. It is of importance to the farmer, because stock properly fumigated comes to him free from many of the pests that are apt to attach themselves to young trees in nursery rows. But fumigation is a process and not a mere word; like everything else, it can be done properly and effectively, or improperly and ineffectively. I have referred to the subject in several of my reports, but have never given it a place in New Jersey orchard practice. Nor have I changed my views on this point, but am impelled to go into the subject somewhat more in detail on a subsequent page, because in this process and its effect lies the only real protection against the distribution of infested nursery stock.

Inspections.

The work of the State Entomologist increases as the pernicious scale continues to spread and fruit growers in the late-infested localities awaken to the danger. Had I accepted all the suggestions made to me of places to be visited it would have taken nearly my entire time for the year. Several trips were undertaken so as to spend an entire day inspecting the orchards of one district, and, in a number of cases, informal field meetings were held, at which I was able to demonstrate to those in attendance the character and injury caused by the scale and the manner in which it caused the mischief complained of.

The general interest thus awakened reacts upon the nurseries, and it has become practically impossible to sell stock uninspected and not certified as clean. The consequence is that this department is called upon more frequently than ever to inspect the small nurseries growing only single blocks of trees for sale, which in the past paid no attention to either the requirements of the law or the interests of those who bought from them. The number of letters of inquiry from would-be purchasers is also increased, and, again and again, questions come as to whether this, that or the other nursery is a safe one to purchase from.

It has always been the policy of this department to assist nurserymen just as far as possible, consistent with the interest of those that purchase from them; hence, nurseries have not only been more closely inspected than ever before, but inspections have been made at times when, under the State law, the nurserymen neither desired nor were entitled to them. Despite the utmost efforts of their owners, nurseries in some sections of the State are so situated that infection to a greater or less extent is almost unavoidable, and the problem has been, not only to keep out the scale so far as possible, but to destroy such as may come in despite the precautions observed. To this end nearly all the nurseries are now provided with fumigating houses, and I have been at great pains to impress upon the growers the importance of careful and thorough treatment of the stock. Other States are making their inspection laws more rigid than ever before, and their enforcement is placed upon a much more effective basis. Adequate appropriations are made, sufficient, in many cases, to make a real police inspection possible, and, as in New York, for instance, to

keep inspectors in the field during the entire year, with ample powers to enforce their decrees. In that State any certificate is accepted, and even stock without certificate is admitted. But once it is delivered within the State, it is closely examined by employes of the State Department of Agriculture, and, if on any consignment any appearance of scale is found, the doubtful trees are destroyed and all the others are fumigated, whether they had been previously submitted to this process or not. If scale is discovered at all, the infested tree is destroyed without attempt to discover whether the insect is dead or alive. In this stand, New York approaches the Californian practice, and it is a question whether, after all, this is not the real solution of the whole problem. If each State would simply tend to matters within its own borders and destroy all infested trees brought in, it would not be long before nurserymen from without its boundaries would become very cautious as to the character of the stock they shipped. As matters stand at present, New Jersey has very little real protection against infested stock from other States and none at all against the distribution of infested stock grown within its own borders. The appropriation made to the State Entomologist suffices to pay traveling expenses and part of the salary of an assistant who makes inspections, but no more. The Entomologist himself gets no compensation, and the duties imposed upon him are in addition to those which he owes to the Experiment Stations and to the Agricultural College, from which he draws a salary. The Insect Commissioners are active within their jurisdictions, but they can act only on complaints and have no power to incur expense. It is not only in New Jersey that conditions begin to approach the intolerable, and, at meetings of the official inspectors, held at Washington, in November, 1901, and Atlanta, in October, 1902, the whole subject was thoroughly discussed. An organization was effected whereby each inspector who meets infested stock from States other than his own notifies the official concerned of his discovery and puts him in position to trace the source of the infestation. Nevertheless, the whole subject is in an unsatisfactory state, and a committee was appointed by the chairman at the Atlanta meeting, to which was intrusted the task of studying conditions as they exist under present laws and to recommend such legislation as would seem desirable to conduce to uniformity of practice in interstate commerce.

The mandatory powers of the law within State limits have not

been applied in any case during the past year. It is realized that persuasion accomplishes more in the long run than attempts at compulsion, and, therefore, I have always tried to prove the necessity for active measures from the standpoint of self-interest for the grower concerned.

Collections.

No important single additions were made to the collections, but a great many specimens were added in the course of the year from gatherings made by Mr. Dickerson and myself. Several cases have been arranged, and scientific study has been made of one group among the owlet moths. A number of boxes were prepared for the State Museum, at Trenton, and thirty-five are now on exhibition. The collections of the Department, belonging partly to the College and partly to the Station, have become of really great importance and value, and deserve a safer housing. The scientific value of the types alone is very great and the study value of the collection is difficult to estimate in terms of money. In certain families of the moths, the collection is unsurpassed by any in the United States.

Miscellaneous.

During the summer I attended the meeting of the Association of Economic Entomologists at Pittsburg, and, in the general discussion, became familiar with what was doing and what had been done in other States. The chief subjects for discussion were the pernicious scale and the periodical cicada, but other topics of economic importance were not wanting, and the meeting was a very profitable one from all points of view.

My connection with the entomological societies at New York City, Brooklyn, Philadelphia and Newark has been maintained, and, as usual, I have received information that has been of use to me in my work, from the individual members.

To the Division of Entomology, in the United States Department of Agriculture, and to the gentlemen on the staff of that division, I am indebted for information and for assistance, as is specifically acknowledged elsewhere.

Formal lectures, informal talks and addresses have been delivered at indoor and outdoor meetings of farmers, before clubs, at picnics,

harvest homes and at county board and institute meetings all over the State. To many hundreds, direct information has been brought on topics of present interest to them, and the results are slowly becoming apparent in the more general adoption of better practice.

Addresses have been also made before the State Board of Agriculture and before the State Horticultural Society, at their annual meetings, on topics relating to my Department.

The correspondence of the Department is greater than ever before. At least 3,000 separate communications are recorded on 2,000 pages of letter books, and this does not include circular letters to commissioners, board of health officers, etc.

During most of the year I have had the assistance of Mr. E. L. Dickerson, who has acted as my deputy in making nursery inspections and has relieved me of much manual work in the Laboratory.

EXTRACTS FROM THE CROP BULLETIN.

The season began April 30th, with my request for records on the appearance of the periodical cicada, and, as this subject is covered elsewhere in this report, no further reference to the matter will be made under this heading.

San Jose Scale has the honor of the first record, from Fairlawn, Bergen county. At Freehold, Monmouth county, some trees were said to be injured; at Franklin Park, Middlesex county, many trees are affected, and at Martinsville, Somerset county, farmers were "spraying for the San Jose scale." Four records for the first number of the Crop Bulletin indicate a much more general interest in the subject than in the past.

May 6th the insect was reported from Beverly, Burlington county, as damaging apple trees. May 12th, it was recorded from Paterson, Passaic county, that the scale had appeared in abundance. Not until June 24th was the insect again referred to and then from Martinsville, Somerset county, where it was injuring fruit trees. August 15th, Mr. Beans reports from Moorestown, Burlington county, that in the peach district this insect had injured many trees. This ends the record, which is rather scanty for the most destructive species occurring in the State.

Tent Caterpillars were noted on apple trees as early as April 30th, at Kingwood and Rowland's Mills, both in Hunterdon county. May 6th, they were very numerous at Ocean View, Cape May county.

May 12th, they had made an appearance at Pittstown, and were troublesome at Rowland's Mills, both in Hunterdon county. May 20th, they were unusually troublesome at Huntsburg, Warren county, and their appearance was noted at South Bound Brook, Somerset county. May 27th, they were more numerous than usual at Kingwood, Hunterdon county. June 3d, some trees were stripped of their foliage at Huntsburg, Warren county, and at Frenchtown, Hunterdon county, they were troublesome. This is probably the last record referring to the real tent caterpillars, and later reports, under the same general terms, apply almost certainly to the fall web-worm.

A few *web-worms* were noticed, June 17th, at Freehold, Monmouth county. July 1st, they were troublesome at Kingwood, Hunterdon connty, and numerous at Cape May, Cape May county. July 8th, they were quite numerous on the fruit trees on the College Farm, at New Brunswick; they were injurious to such trees at Farmingdale, Monmouth county; were numerous at Hightstown, Mercer county; numerous and destructive to fruit trees at Salem, Salem county, while at Moorestown, Mr. Heritage states, they were abundant, and that not enough spraying was done to destroy them. July 15th, they were bad on fruit trees at Egg Harbor City, Atlantic county. August 19th, they were numerous at Ocean City, Cape May county, and this was the last record of the season, as well as the only one that probably refers to the second brood. The first brood became so abundant in late June that in the Bulletin for July 1st I inserted a note cautioning fruit growers to keep a lookout for a possible dangerous increase later on.

"Potato Bugs" were first reported May 12th, from Farmingdale, Monmouth county, and were already troublesome at Sewell, Gloucester county. May 20th, they were troublesome on the early potatoes at Rocksburgh, Warren county, and on Jnne 3d they were so at Frenchtown, Hunterdon county. June 17th, they were reported from Cranford, Union county, and July 1st they attracted attention at Ardena, Monmouth county, and at Frenchtown and Kingwood, both in Hunterdon county. This ends the season so far as this insect is concerned, and reports are altogether less numerous and injury is less complained of than usual.

Plant lice were troublesome on some crops, and the first to be noted is the *apple louse,* which affected some orchards at Mickleton, Gloucester county, May 12th.

Plant Lice on tomatoes were first reported from Sergeantsville, Hunterdon county, June 3d, as doing some damage. Not until July 8th was there another complaint and then it came from Woodstown, Salem county, where the late tomatoes were said to be fair, except for this infestation. July 15th, Hightstown, Mercer county, reports tomatoes as badly infested, and at Swedesboro, in Gloucester county, the insects were doing much injury. July 22d, injury was reported from Medford and Mount Holly, both in Burlington county, and on the 29th of that month, Clayton, Gloucester county, and New Egypt, Ocean county, made complaints to the same effect, closing the season so far as this insect is concerned.

Plant Lice killing clover, in places, was reported from Mickleton, Gloucester county, June 17th, and on the 24th, South Bound Brook, Somerset county, places the loss from these insects at two-thirds of the entire crop.

Plant Lice on melons were noted at Mickleton, Gloucester county, June 17th, and not again until August 5th, from Landisville, Atlantic county. In neither case was specific injury claimed.

Root Lice on corn were reported once only—July 1st, from Layton, Sussex county.

Lice on lima beans were very troublesome at Trenton, Mercer county, July 15th, but, apparently, attracted attention nowhere else.

The most satisfactory record came from Freehold, Monmouth county, August 12th, and read: "Very few plant lice this year."

Currant and Gooseberry Worms appeared in troublesome numbers at Flemington, Hunterdon county, May 20th, but seem not to have been abundant elsewhere.

Cut-worms were first reported cutting cabbage and tomatoes, May 20th, at Clayton, Sussex county, and on June 24th they were damaging corn, tomatoes and garden truck at Salem, Salem county—a very brief record for these insects.

Rose-bugs were numerous at Cape May Court House, Cape May county, June 10th, and "very destructive" at Ocean View, in the same county, on the same day.

The *Curculio* is credited with injuring fully half the apple crop at Cold Spring, Cape May county, and is not again referred to.

The *Codling-moth,* also, is reported once only, as causing apples to drop at Martinsville, Somerset county.

Asparagus Beetles, or rather their larvæ, were numerous and causing damage at South Bound Brook, Somerset county, July 22d.

Cabbage-worms were abundant enough to be troublesome at Kingwood, Hunterdon county, August 12th.

The *Angoumois Grain Moth* was reported as threatening the entire wheat crop at Shiloh, Cumberland county, July 22d.

In the last Bulletin of the season, September 16th, Somerville, Somerset county, reports "no winter grain sown yet for fear of the Hessian fly," but this stands out against numerous other reports of seeding completed or in progress.

A very general report came from Readington, Hunterdon county, July 8th, that corn is "growing, where not eaten by insects."

From Beverly, Burlington county, we learned, July 15th, that there was "considerable spraying done," but of what sort is not stated.

Altogether, based on the crop reports, this season seems to have been remarkably free from serious insect troubles.

THE EXPERIMENT ORCHARD.

No detailed record was made in the report for 1901 of the work done on the trees grouped under the above term. For various reasons it was deemed best to bring together all the work previously done into bulletin form, giving suggestions, incidentally, as to methods of dealing with the common orchard pests.

During the past summer the trees have been somewhat neglected and some of them have become very scaly. Others of them were so close to the fence adjoining the street or the College athletic grounds that the fruit attracted the attention of those members of the boy tribe that consider natural products free for any who can take them. The trouble so caused induced me to take out a number of the peach trees and no others were set to replace them. Nevertheless, some observations were made and some experimental work, chiefly with lime mixtures, was done which merits record. As it is also intended to test the "Calcothion" rather carefully during the coming winter, the present condition of the trees is a matter of importance. The records begin where those in Bulletin No. 155 end, unless it is necessary to explain an existing condition from a previous happening.

General Notes.

An examination to determine the general condition of the trees was made March 30th, after a heavy rain; another, to determine the stage of the blossom buds, was made April 16th, and a more general inspection was made April 18th, after a period of warm weather. April 21st, the trees which had blossoms were noted, and on the 22d, 23d and 30th other notes were made, the weather being decidedly warm and rather dry. The first week in May continued warm, with some rain, but the temperature dropped after the 8th, and for three nights before the 12th approached the frost line. The weather remained cool until the 16th and 17th, when I applied a dressing of mixed fertilizer samples on all except trees 37 to 40, inclusive, forking it in for a distance of from two to three feet from the trunk. A little period of warmer, cloudy weather followed, and on May 23d, a cloudy, sultry day, I whitewashed the trunk and base of the larger branches of trees 12, 14, 15, 16, 17, 18, 19, 20, 21, 26, 28, 30, 35 and 43. The whitewash was of good body, heavily salted, and was applied with a brush. Then came a series of heavy showers and, before June 1st, one day of solid rain; all of which sadly marred these lime-coatings.

June 9th, sprayed apple, plum and walnut with arsenate of lead to check web-worms, and on the 11th sprayed the pears as well. On the 22d, developing nests were seen on trees 5, 15, 16 and 38, and these were again sprayed with arsenate of lead. No care was used in getting this arsenate of any particular strength, but it approached very close to one pound in ten gallons of water, and is so referred to.

Black Insecticide Soap

July 5th was a hot, sunny day, and I applied "black soluble insecticide soap" to trees 4, 5, 12, 19, 32, 36, 39 and 42. This soap has been qnite well advertised, and the makers or importers claim for it a European reputation, as well as a gold medal gained in competition with all other insecticides at some Italian exposition. They have been persistent in their efforts to secure an endorsement of the material and claim that it kills scales, plant lice, the leaf rollers of the vine, etc.

A small keg of the soap was purchased, and on the afternoon of

July 4th I dissolved it according to directions and let it stand until next day. The solution was made much stronger than recommended, and, when diluted for application, trees 4, 5 and 12 received one pound in about seven gallons of water, and the others, one pound in about six gallons of water; both much stronger than recommended. I used no more concentrated mixture because I feared possible injury to the foliage. Every tree was sprayed to a drip from two sides quartering the wind, and, so far as possible, against it. The fruit was as thoroughly drenched as the foliage and I doubt whether anything escaped a wetting. No benefit could be observed, when examinations were made during several days, and I could not be sure that even a single active larva had been killed. At all events, they became so numerous that, after a general inspection made July 12th, I sprayed trees 4, 12, 38 and 39, on a hot, dry morning with the soap at the strength of one pound in two gallons of water, with exactly the same results as before.

I notified the dealers of my results and received expressions of surprise and fear that I must somehow have received a lot of material that had long been made up and had deteriorated; they would send me another fresh lot for further trials. They did send it, and on July 28th I sprayed trees 19, 21 and 39 with a mixture of one pound in two and one-half gallons of water. No good effects were noted yet. On August 10th I used one pound in two gallons of water on trees 17, 18, 19 and 21, making the applications very thorough on all except tree 17, which received a short dose because the material gave out.

This is about the least effective material I have ever tested and is about as little harmful to the insect as it is to the trees. The price is as high as the stuff is ineffective, and all persons desiring to buy a real insecticide should avoid Cassaza's black soluble insecticide soap.

Agricultural Soap.

Another material received for trial was an "agricultural soap," made by a good firm for experimental use. The material was soft, dissolved rather readily in hot and rather slowly in cold water. Applied it June 24th on apple and pear and found it more of a task than I had bargained for. Evidently there was resin in the mixture, and before long, nozzles, valves, stop-cocks, etc., were all glued fast

and could scarcely be stirred. Hose, spray-rod and pump handle became so sticky that care was required lest, in letting go any of these, a piece of skin be left behind.

Before I could use the machinery again it was necessary to take everything apart and wash in hot water to remove all trace of the soap. When I notified the makers they agreed at once that such a material was better kept off the market.

As to the effectiveness of the soap there was little chance to form a judgment, because there was a very heavy rain during the night of the 24th, and next day, when things dried off, no noticeable destruction of scale had resulted. But there was a whitish deposit, probably resin, on all the treated surfaces, and it would not be fair to condemn the soap as valueless for insecticide purposes on such evidence were there no other objections to its use.

July 23d, placed specimens of adult *Chilocorus similis* under the cages over trees 32 and 36. This matter is more fully explained elsewhere in the Report and needs only a mere suggestion here.

August 24th, everything was swarming with larval scale insects and it began to seem as if some work would have to be done. So, on September 1st, I sprayed all the very badly-infested trees with whale-oil soap (Good's No. 3) at the rate of one pound in two and one-half gallons of water, and the application was very successful.

September 8th, applied ground tobacco about the roots of all trees save Nos. 32 and 36, and on October 2d examined all the peach trees for borers; none were found. No cement coating was applied this year, for there are now no other peach trees within easy range of my grounds.

Frost, hard enough to kill the leaves, came on the night of October 22d, and active breeding ceased about that time. Scale larvæ were found after November 1st, but in small numbers.

It should be said that in February there was a very heavy sleet storm, which severely injured trees throughout many sections of the State, and that the Experiment Orchard did not entirely escape.

Tree 1—*Mariana Plum*. March 30th, buds were swelling and showing green all over. Plenty of scale in centre of tree on old wood; less outwardly, and the new shoots were practically clean. The tree had been somewhat broken by the sleet storm and the broken shoots were then cut out, as were some of the interfering newer shoots. It moved slowly until leaf buds began opening April 18th, and the

blossom buds began to separate. The first flower opened April 22d and on the 25th the tree was in full bloom.

April 28th, sprayed trunk, main branches and a little foliage with Calcothion.

May 1st, bloom was almost gone, the trees were advancing and I made another local application of Calcothion, avoiding foliage as far *as possible. May 4th, the little shoots hit by the spray were drying* up. May 7th, I again applied the mixture on the trunk and inner branches. *May 12th, all the young shoots and foliage hit by* the material were dead. On the 7th a little fruit had set and more twigs were dead. Examined some parts of the treated area and found no live scales. The fruits dropped one by one until, July 4th, only half a dozen were left. At this time there was no breeding, but a few new scales were observed on the new wood. July 12th, the scale on the lime-washed area was dead and dry; plenty of scale on last year's wood; very little on the new growth. August 12th, all the fruit was off and the tree was growing rankly; scale situation unchanged. October 22d, was yet in full foliage and the scale was certainly less than last month, the old wood clearing up nicely; but there was plenty of live scale and some shoots were very bad. Cut off two of the lowest branches, which were near the ground and much shaded by the fence.

TREE 2—*Yellow Transparent Apple.* Trimmed back well during the winter, taking off half of the new growth. Buds were swelling March 30th, scattering scale was all over the tree and four specimens of the two-spotted lady-bird were feeding on it. April 23d, leaf buds opened, and May 7th, was in full leaf. On that day sprayed trunk and base of main branches with Calcothion, avoiding foliage so far as possible. May 12th, that which was hit was dead and drying up. June 9th, sprayed with arsenate of lead to kill web-worms, and up to the 17th it killed all as fast as they developed. On that day the lime was all off. This tree has a very smooth bark and was sprayed for that reason to test sticking quality of mixture. Up to July 12th no larvæ were observed on the tree, but there was a little fresh scale on the new wood, which may have come from outside. The trunk and branches at that date were almost free from scale, and most of what remained was dead.

August 12th, growth had stopped, the leaves were much affected by leaf-hoppers and there was more scale on the new wood. August 15th, took off two colonies of web-worms and sprayed with arsenate

of lead. Leaves began to die and some to drop August 21st, and on September 1st crawling larvæ were rather abundant. Sprayed with Good's whale-oil soap, No. 3, one pound in two and one-half gallons of water, and made the application very thorough. The leaves were perceptibly scalded September 8th, but the larvæ and recent sets were wiped out.

October 22d, about 60 per cent. of the foliage was off and the balance was dry and lifeless. Scale was all over the tree, but nowhere bad; less on the trunk and base of branches than elsewhere and more on the ends of the new growth than anywhere else.

Two points are noticeable in this connection—the good effect of the arsenate of lead in keeping down the web-worm colonies, and the fact that little attempt was made by scale larvæ to set on the trunk and base of branches, even late in the season, when all apparent trace of the sulphur wash was gone.

Tree 3—*Black Tartarian Cherry.* Buds had started March 20th, but were not free until April 16th; on the 18th leaf buds were opening, the white of the blossoms began to show, and on the 21st half the flowers were open. The scant bloom was full on the 22d and the foliage was almost complete. May 1st, all the bloom was gone and the tree was in full foliage. A very scant set of fruit was made; the plum curculio attacked some of these and the robins got everything else as soon as it was anywhere near ripe.

The tree grew well throughout the season, and on October 22d, while I could find an occasional scale, there had been no recent breeding.

Tree 4—*Abundance Plum.* March 30th, buds were well advanced and blossom clusters were separating. Little trimming had been done; there was some scale everywhere to the tips of the shoots, and locally it was pretty bad. April 16th, blossom clusters were free and many were showing white; on the 18th they began to open and on the 22d all were out full. Petals began to drop on the 23d and on the 28th only a few scattered flowers were left.

May 7th, sprayed trunk and base of branching with Calcothion. There seemed to be a fair set of fruit on the 17th, but it had developed irregularly. June 1st, only a small crop remained; much of it attacked by curculio, and on the 17th scale breeding was active. The Calcothion was yet visible and there was no breeding where this had been applied. June 24th, sprayed thoroughly with the "agricultural soap," referred to in the general notes. July 4th, found

scale larvæ active, but little was on the new wood and none on the fruit. July 5th, sprayed with black soluble insecticide soap, one pound in a little over seven gallons of water.

July 12th, a dozen ripe fruits of fair size were taken off, most of them wormy, and a few cripples remained on the tree. No scale was on the fruit, but larvæ were swarming on some branches, fixing mainly on last year's wood and on the leaves. On the 15th, sprayed the worst infested shoots with the black soap, one pound in two gallons of water. Absolutely no benefit was noted, and on August 12th some of the branches were horribly scaly. Larvæ were active and were extending down the trunk.

October 22d, foliage was yet complete, but bronzed; the tree was generally scaly and in some places horribly incrusted; so much so that the shoots have become lifeless and break under the least strain.

TREE 5—*Bartlett Pear.* March 30th, trimmed off about half the new growth. Not much scale, but the sinuate borer had killed a large area on the trunk. April 18th, leaf buds were ready to open, and on May 7th it was in full foliage and growing nicely.

June 17th, there was a little pear slug; one nest of web-worms was removed and scale breeding had begun. On July 4th the larvæ extended clear to the tip of the new shoots and even on to the leaves. On the 5th, sprayed with black insecticide soap, one pound in a little over seven gallons of water. On the 12th there was not much change; there were no active larvæ, no recent sets and the tree had stopped growth. August 21st, there was a new brood of larvæ and many white sets were found. Some of the leaves were already dropping, and on September 1st I drenched with Good's soap at the rate of one pound in two and one-half gallons of water. September 8th, no bad effects were noticeable on the tree; the larvæ had been wiped out and so had some of the more recent sets; but the breeders were unhurt.

October 22d, foliage was partly off and most of it dropped at a touch. It was now a very scaly tree and some shoots were incrusted. No moving larvæ, but plenty of young under the mother scales. Three, and perhaps four, sinuate borers are in this tree.

TREE 6—*Pleasant Valley Pippin.* March 30th, the tree had been trimmed to a symmetrical head and buds were beginning to swell. Some scale all over the tree and less on the trunk than elsewhere. Buds started April 18th; was in practically full leaf May 1st, and several blossom clusters were developing. On the 7th, sprayed the trunk and base of branches with Calcothion. Blossom clus-

ters out full. Where foliage was hit it was killed on the 12th, and up to the 17th no fruit had set. June 17th, ten fruits had begun to develop, chiefly on one branch, the lime wash was all gone and scale breeding had begun. On the 24th I applied the "agricultural soap" most thoroughly. July 4th, there seemed to be less scale, and much of it was dead. One branch, bearing three fruits, had wilted and was cut off. On the 12th the trunk and base of main branches were free from scale, but there was a liberal set on the outside and a little on the fruit. Below the branching there was an area of dead bark, which threatened the life of the entire top. On August 12th the dead area had extended completely round the trunk, and the leaves were beginning to turn yellow, to wilt and to drop.

September 1st, took off the few remaining apples, which were then about ripe. The top was dying, scale larvæ were now swarming and I had the tree cut down. It had been very scaly ever since it was set, had never grown very much, had suffered about all the kinds of insecticides I ever used, and died at last from general lack of vitality. There was no mechanical injury where the trunk died; it was a drying up and blackening, like the body blight of pear.

Tree 7—*Champion Peach.* The tree was cut back pretty well, but left with a fair set of fruit buds, badly distributed because the shoots were too long.

March 30th, blossom buds were swollen and leaf buds tipped green; some scale all over tree. April 18th, leaf buds had started and one blossom was open; on the 22d one-fourth of them were out, and on the 23d it was practically in full bloom. On the 28th sprayed trunk and base of larger branches with Calcothion, and on May 1st duplicated the application, extending it a little further among the branches. Bloom was all gone and a fair set of fruit indicated May 7th, and at this time the small shoots making from the inside branches were pretty well gone as the result of the spraying. Practically all these were killed off, and on June 1st there had been no new start from the sprayed area. The wash held well and no breeding was observed until July 12th. At that time everything on the lime-treated area was dead and very little live scale was noted anywhere. The trunk was still lime-coated and was very rough and scaly. A month later there was enough live scale scattered about to make a very decent infestation, but there were few active larvæ. The fruit had taken a start and made great gains in size and color.

August 14th, sprayed with arsenate of lead, one pound to ten gallons of water, to discourage fruit feeders. On the 22d the tree was raided by a gang of street loafers, and to avoid further trouble all the fruits were removed, though not quite ripe. The crop was fair and the fruits were of extra size and very good quality.

October 22d, was yet full in foliage, not very scaly, not much on the new growth and no crawling larvæ. The tree was making its fruit buds badly, partly due to bad pruning and partly due to killing off the inside shoots with Calcothion. No new shoots started on the sprayed area, and it seems indicated that on peach trees the lime, salt and sulphur wash must not be used too late in the season. The shoots were killed down to their base, and, apparently, a start from dormant buds was prevented.

TREE 8—*Grimes' Golden Pippin*. The tree was cut back during the winter and more than half of last year's growth was taken off. April 18th, it was starting well, some leaflets were unfolding, and by May 1st it was practically full leaf; there was no bloom. May 7th, sprayed with Calcothion the trunk and base of larger branches, avoiding foliage so far as possible. On the 12th such foliage as was hit was drying up. June 9th, sprayed with arsenate of lead, and on the 17th I noted that several nests had started and been nipped in the bud by this application. Scale breeding had begun and some white scales were found. On the 24th sprayed with the agricultural soap. July 4th, there was considerable scale locally, mostly on last year's wood. The trunk still showed the lime coating and little live scale. Several other nests of web-worms had started, but only one had become established, and in it I found a few live caterpillars. On the 12th no living scales were on the trunk or base of the larger branches, but there were plenty on last year's wood. Leaf hoppers were also plentiful. A month later growth had stopped, leaf hoppers were present in large numbers and a full brood of scale larvæ was moving. August 15th, sprayed with arsenate of lead, to kill off the second brood of web-worms, which was beginning to show. On the 21st the tree was fairly swarming with larvæ and recent sets.

October 22d, the tree was yet in full foliage, but was a real bad case of scale infestation. There was not much on the older wood, but outwardly the new growth was fairly incrusted—even the leaves were set full and many of the fruit spurs are probably killed. There were plenty of active larvæ and dozens of *Pentilia misella*.

This is a well-shaped, apparently vigorous tree, and its complete coating of scale, from a start after the middle of July, is an interesting example of the possibilities of the pernicious scale on a susceptible tree.

TREE 9—*Champion Peach.* The tree had been cut out pretty well during the winter, leaving the fruit buds located well out on the shoots. They began plumping out March 31st, with plenty of scale, mostly dead, on the old wood and little on the new growth. April 18th, leaf buds were developing and some blossoms were ready to open. On the 21st several had opened, and on the 23d the tree was in full bloom. May 7th, was leafing out fairly and not yet all out of bloom. Shoots were making all over the lanky main branches, and this promised to be a good subject for the dehorning process. June 17th, the fruit was developing normally, the scale had begun to breed and the inside shoots were growing well. July 4th, there was an abundance of larvæ, but they did not seem to get out much—setting on leaves and inside branches rather than on the shoots. August 12th, the fruit began to color up, there was not much scale anywhere and very little on the rough, scaly trunk. On the 15th sprayed with arsenate of lead, one pound in ten gallons of water. On the 22d a raid was made by street loafers, and to avoid further trouble the fruit was taken off, unripe. The crop would have been fair and of extra quality. This was proved by the few ripe examples that were actually obtained.

October 22d, the tree was yet in full, healthy foliage, scale was all over it and, in some places, pretty thick. There were no crawling larvæ, but many recent scales. The tree has made a very good inside growth and has developed some fruit buds there. Standing, as it does, in a fence corner, the tendency is to make a lanky growth, and this tendency was not sufficiently checked in the beginning of the growth by proper pruning.

TREE 10—*Late Rose Peach.* Was so badly broken by the February sleet storm that it was deemed best to take it out.

In March a clean Greensboro peach tree, trimmed to a straight, four-foot stick, was placed near the place where No. 10 was taken out, and will bear the same number. It grew well during the season and was a little scaly in late October.

TREE 11—*Late Rose Peach.* Was so badly broken in the February sleet storm that it was taken out and no other set in its place.

Tree 12—*Fox Seedling Peach.* Was somewhat broken by the sleet storm and pretty well cut back. March 31st, the buds were plumping out, there was plenty of scattered scale, but much of it was dead. April 21st, a few flowers were open; on the 23d it was in full bloom, and on the 28th it was dropping petals fast. All the bloom was off May 7th; it was leafing out full and new shoots were making along the bare, inside branches. On the 23d whitewashed the trunk and larger branches at base. June 17th, scale breeding had begun and the lime coating was yet quite complete. July 4th, there was yet some lime on the trunk and no scale had bred on the treated area. The new growth was throwing off scales, but there was plenty on last year's wood and on the leaves. On the 5th sprayed with the black soluble insecticide soap, at the rate of one pound in a little more than seven gallons of water. No marked benefit resulting, I sprayed again on the 15th, aiming at the older, most infested wood, to the neglect of the outer shoots. The mixture was one pound in two gallons of water. No benefit resulted, and on August 12th the base of the new shoots was very scaly and some of the older wood was coated. On the 24th many of the unripe fruits were knocked off by loafers, but nearly half a basket was harvested in September, only fair as to size and quality. As the situation of the tree was such as to invite raids from the hoodlum element, it was cut out on October 22d.

Tree 13—*Fox Seedling Peach.* Was so badly broken in the February sleet storm that it was taken out.

Tree 14—*Seckle Pear.* The shoots were a little shortened in during the winter, and on April 18th leaf buds were starting well. May 1st, it was in full foliage, and on the 23d applied a coat of whitewash to the trunk. This was off June 1st, and on June 11th sprayed with arsenate of lead, to keep off web-worms. Several had started and had been killed up to the end of June, but on July 4th I found and removed a small brood of well-advanced larvæ. At that date the scale was breeding and young were setting toward the tips of the new growth, which had stopped. August 12th, scale was all over the tree and about ready to multiply.

October 22d, most of the foliage was off and last year's growth was coated with scales; even the leaves were scaly. This tree is almost buried in very tall blackberry bushes, is overshadowed by tree No. 37 and may have to be abandoned.

TREE 15—*Japan Golden Russet Pear.* Buds were well advanced March 31st, and on April 16th the blossom clusters were separating and already well advanced. On the 23d one blossom was open and on April 30th all were out. May 1st, petals began to drop, and on the 7th most of them were off. May 18th, had made a full set of fruit, and on the 23d applied a coat of whitewash to the trunk and larger branches. The mixture stuck well to July 4th, and there was no scale where it had been. August 12th, growth had stopped, there was no scale on the fruit and very little anywhere else. On the 24th fruit was beginning to crack, but there was much less codling moth than in any previous year.

TREE 16—*Japan Golden Russet Pear.* Has practically the same history as No. 15 and has received the same treatment. It set a little more full and matured more fruits, but they were smaller and more of them cracked. There is, perhaps, a little more scale, but the condition under which it occurs is the same.

TREE 17—*Keiffer Pear.* March 31st, the buds were breaking into blossom clusters, which became separated April 16th. More than half the new growth had been cut off during the winter, and there was a scattering of scale all over the tree.

Blossoms began to open April 22d, and were practically all out on the 25th. May 7th, the tree was in full foliage and all the bloom was gone. May 18th, a moderate set was indicated and one fruit infested by pear midge was found. There was a heavy drop by the 23d, including most of the midge-infested fruits; but I removed at least twenty others and destroyed them. Applied a coat of whitewash to trunk and base of branches. June 1st, most of this had washed away, and on the 17th it was nearly all gone. No scale breeding was noted and the fruit was developing well. June 24th, sprayed with the agricultural soap. July 4th, there was some scale, in all stages, all over the tree, but more on the fruit than elsewhere. No advantage from the spraying. August 10th, applied the black insecticide soap to the south side. The tank emptied before the north side was completed, but there were some thick dregs which I put on, to see if harm would be done. On the 12th the soap had had absolutely no effect and the fruits were getting very scaly. Foliage began to drop on the 21st, and only a little fruit remained. September 1st, the entire tree was very scaly, leaves and fruit were both dropping, and I sprayed with Good's whale-oil soap, No. 3, one pound in two and one-half gallons

of water. On the 8th the leaves seemed considerably scalded, but practically all the crawling brood was wiped out.

September 10th, what remained of the fruit was ripening. When picked it was of excellent flavor, undersized for Keiffer, but with more Bartlett than Keiffer texture and flavor. October 22d, foliage was about all off, but the wood seemed healthy and the fruit spurs were plump. Some scale all over the tree, but no coating. There are indications of several sinuate borers and depressions for at least three pupal chambers.

TREE 18—*Keiffer Pear.* The tree had been sharply cut back during the winter, and March 31st the buds were well advanced and breaking out into clusters. Scale all over tree, but not much on trunk, which, however, harbors several sinuate borers and has an area of body blight.

Blossoms began to open April 23d; 75 per cent. were out on the 25th, the balance came out a day or two later, and on May 1st the petals began to drop. May 7th, the tree was in full foliage and the flowers were all gone. May 18th, the set was moderate only and fully half the sets were midge blighted. On the 23d, after I had removed all infested pears, only a scanty set remained. On this day applied a coat of lime on trunk and lower branches, which was very imperfect on June 1st. On the 17th the lime was about all gone and there had not yet been any breeding. July 4th, scales in all stages were scattered over the tree and the fruit had comparatively more than any other part. On the 12th conditions were no better and some fruit was very scaly. August 10th, applied black insecticide soap so as to drench, but on the 12th there was no apparent benefit; there were just as many scales as there had been before the application. On the 21st both fruit and foliage were dropping, and on September 1st the fruit was undersized and scaly. Leaves and fruit continued to drop, and I sprayed with Good's whale-oil soap, one pound in two and one-half gallons of water. On the 8th practically the entire crawling brood had been wiped out, without harm to the foliage. Fruit began to ripen on the 10th and, as in the preceding, was of exeellent quality.

October 22d, the tree was scaly throughout and in some places very much so; but no breeding at that time. About half the foliage was off and sinuate borers were indicated at three points.

TREE 19—*Keiffer Pear.* Was sharply cut back during the winter; had scale all over, except on the trunk, the latter slit all around over areas of body blight. Sinuate borers evident. Buds were well

advanced March 31st, and blossoms clusters became freed April 16th. On the 23d a few flowers opened, and by May 1st the petals began to drop, the tree being then in full leaf. May 18th, there was a light set, badly infested by the midge, from which fruits were picked off, from time to time, until, on the 23d, there was only a scant remnant. On that day whitewashed the trunk and base of branches. June 17th, the wash was about all gone and scale breeding had begun. On the 24th sprayed with the agricultural soap; but on July 4th active scale was all over the tree, extending to the tips of the new growth and covering the fruit. On the 5th sprayed with black insecticide soap, one pound in six gallons of water. On the 12th conditions were no better, and on the 28th drenched with the black soap, one pound in two and one-half gallons of water. The application was repeated, at the same strength, August 10th, and on the 12th there were more young and white sets than ever before. September 1st, this was a very badly infested tree, and I sprayed with Good's soap, one pound in two and one-half gallons of water. On the 8th quite a lot of leaves were scalding, but practically the entire crawling brood was wiped out. Only a few fruits ripened properly, and on October 22d all the foliage was off, the tree was only moderately scaly and several sinuate borers are noticeable in trunk and branches.

Tree 20—*Meech Quince.* Cut back moderately, leaving a lot of little branches, which seemed free from scale. Buds were pointing out March 31st, but did not really start to unfold until April 23d. Was in full foliage May 12th and a few blossoms were opening. Was practically out of bloom May 23d, and I whitewashed the trunk to the branching. June 1st, there were three well-set fruits and most of the lime was off the trunk. June 11th, sprayed with arsenate of lead, which, by the 17th, had killed off several nests of web-worms. A few more blossoms were out, but no more fruit set. Two undersized fruits matured, and on October 22d the tree was yet in full foliage, with the merest trace of scale.

Tree 21—*Keiffer Pear.* Was cut back pretty well during the winter, but plenty of wood was left inside. The main branches all have sinuate borers, there is a little scale all over the tree and at a few points it is massed. March 31st, the bud clusters were well developed, and on April 18th the buds had separated out. Flowers began to open on the 24th; on the 26th it was in full bloom, and on May 1st was also in full foliage. A week later all the bloom was off; only a light set of fruit remained on the 18th, and so much

of that was infested by pear midge that on the 23d only a very little remained. Whitewashed the trunk and base of branches; but by June 17th practically all trace of the lime was gone. July 4th, growth had stopped, scale was active all over the tree, to the tips of new shoots, and over the fruit. Web-worms had been killed off, as they started, by arsenate of lead, applied on the 11th. July 28th, sprayed thoroughly with black insecticide soap, one pound in two gallons of water, and on August 10th repeated the application so as to drench. On the 12th no benefit could be noted from the application, white sets and crawling larvæ being abundant. September 1st, the entire tree, including fruit, was very scaly, and I sprayed with Good's soap, one pound in two and one-half gallons of water. On the 8th some leaves had been scalded and a few had dropped, but the young scales were completely wiped out and not a crawling larva was seen. What little fruit remained ripened about the middle of the month and was very good, though undersized. October 22d, was yet in full foliage, scaly throughout, but not nearly so bad as in September. Less appearance of sinuate borer than elsewehere iu this series, while the fruit spurs are better.

TREE 22—*Japanese Chestnut.* Leaf buds began opening May 1st; blossom sprays were developing June 1st, and were in full bloom July 4th. No fruit set. but the tree grew well throughout the season, and was not the subject of any experiment. October 22d, there were a few scattering scales and the foliage was beginning to drop.

TREE 23—*Greensborough Peach.* This tree replaces a Pride of Franklin, which was so badly broken by the February sleet storm that it had to be taken out. It was clean and cut to a straight, three-foot stick. Had made a good start May 1st, grew well during the season and remained free from scale until October 2d, when some half-grown examples were noted on the trunk, where a label wire had almost girdled it. Was yet in full foliage October 22d, and the scales had not increased in number.

TREE 24—*Greensborough Peach.* Has practically the same history as No. 23, and like it, replaces a Pride of Franklin tree. It had one blossom—a large, showy flower. October 22d, it had made a fine growth, foliage was yet complete and there were a few scales on the older wood.

TREE 25—*Apricot.* Cut off all the shoots that would not tie well to the trellis and shortened in the others. Flower buds showed red March 31st and began to open April 15th. Was in full bloom on the

18th and practically out of bloom on the 23d. No fruit set, but the tree grew well throughout the season, making its usual long shoots. It remained clean until October 22d, when a few scales were observed, the foliage remaining almost complete.

TREE 26—*Nectarine.* Was cut back pretty well during the winter; was clean and making a start April 18th. The tip borer became evident May 1st and increased, as the foliage became more abundant, until May 18th; the leaves were gnarled and twisted and a large percentage of the shoots had been attacked. The trunk was whitewashed on the 23d and the mixture stuck well for a month. On the whole, the tree did fairly well during the season, but became somewhat lopsided from the heavy winds. The foliage was always a little gnarled, but of a healthy color. October 22d, it was yet in full leaf, but there was a little scattered scale on the old wood.

TREE 27—*Cratægus.* A few sprawling shoots were cut out during the winter, but otherwise the tree was left to do as it would. March 31st, the buds were pointing out, and there was a very little scale on the new wood.

April 18th, leaflets began to unfold, and on May 1st it was in full foliage. Plant lice became rather plentiful June 17th and were curling the foliage July 4th. Early in August it made a new start and the scale became more obvious. October 22d, it was yet in fair foliage, a little scaly all over and full of female plant lice, that were ovipositing. There were, already, eggs in large numbers.

TREE 28—*Early Michigan Peach.* The tree was only shortened in a little during the winter and had a few scattered scales. Buds were swelling March 31st, but no blossoms opened until April 22d. Was in full bloom on the 25th and out of bloom, in full foliage, May 7th. On the 18th some tips were curled by plant lice, among which *Adalia bipuncta,* the common two-spotted lady-bird, was busily feeding. On the 23d applied whitewash to the trunk and base of branches, and this stuck well until after the middle of July. No breeding scales were seen June 17th, but the foliage looked ragged and as if infested by shot-hole fungus. The tree grew well, the fruit developed normally and little scale breeding was noted to August 12th. The fruit began to color, and on the 22d it was taken off, unripe, after a raid by street loafers. The crop was sufficient in quantity, and, judging from a few ripened examples, would have been satisfactory as to quality.

October 22d, was yet in full foliage and in general good shape.

Had more scale than at any previous period of its history, but that was not much.

TREE 29—*Gravenstein Apple*. The new growth was considerably shortened in during the winter and a little was cut out. There was considerable scale all over the tree, and in some places a good deal of it.

No start was made until April 15th, and not until May 1st was it leafing out generally. On that day applied Calcothion liberally, aiming primarily at the trunk and branches, but giving the small foliage a good dose in the lower part of the tree. On the 4th many of the smaller leaf tufts were dead and most of the leaves were materially injured. On the 7th applied another coat of Calcothion, which killed everything on the sprayed area and left it completely bare May 18th. A little active scale was observed July 4th, but none on the sprayed area, which yet showed traces of the application. On the 12th there was quite a little on some of the spurs, but a month later it had not increased, and at that time the first nests of the second brood of web-worms were destroyed. August 15th, sprayed with arsenate of lead and no further trouble was had with caterpillars.

October 22d, the tree was yet in full foliage. All the old wood, where Calcothion had been applied, was entirely free from scale and only a little of it was found on the outer shoots. The most interesting outcome of this examination was a twig with the characteristic egg punctures of the periodical cicada.

TREE 30—*Grimes' Golden Pippin*. This tree had made a great deal of inside wood and this was trimmed out very materially during the winter. The bark was rough and had a tendency to scale off, but was sound below this outer coating. There was a little scattered scale.

April 23d, buds were pointing out all over the tree and a few were opening, but not until May was it in full foliage. On the 18th destroyed a colony of woolly lice on a bruised branch, and on the 22d applied whitewash on trunk and lower branches. June 11th, applied arsenate of lead, and on the 17th it was found that this had destroyed several colonies on the first two leaves attacked. Very little lime remained at this time. July 12th, there was very little scale anywhere, but plant lice were becoming quite plentiful on some shoots. A month later matters had not changed much, except that plant-louse injury to the tips of shoots was noticeable and that leaf hoppers were somewhat abundant. On the 15th applied arsenate of lead, one pound

to ten gallons, and this seems to have caused a drying of the leaves, some of which were dropping on the 21st.

September 1st, scale had increased materially and there was a brood of crawling larvæ, so I sprayed with whale-oil soap, one pound in two and one-half gallons of water. This cleared out the crawling brood and killed a little more foliage, as well as a lot of the plant lice that were on the tree; but on the 8th new, active larvæ again made their appearance.

October 22d, foliage was beginning to drop naturally. Some branches were quite scaly; there were a number of colonies of the woolly louse, and on every shoot eggs of the apple louse were in abundance and being added to. This tree seems an excellent subject for every kind of insect attack and offers no resistance at all to their multiplication.

TREE 31—*German Prune.* This tree had grown long, ragged shoots, which were cut back more than one-half during the winter. There was quite a bit of scale and most of it was alive. Leaf buds began opening April 23d, and by May 7th foliage was complete. It grew its usual lanky shoots during the summer; was not made the subject of any experiment, and was in tolerably good condition until October. On the 22d of that month foliage was more than half off, there was more scale than ever before on the older wood and there were plenty of active larvæ to increase the infestation.

TREE 32—*Lawrence Pear.* Was shortened in, a little only; found to be generally covered with scale, and made its start April 23d. Was in full foliage May 7th, and had a little bloom, on which no fruit set. Scale breeding began June 18th, and larvæ had already worked out to the extreme tips. On the 24th sprayed thoroughly with the agricultural soap, and on July 4th found that sets extended to the very end of the new shoots. July 5th, sprayed with black insecticide soap, one pound in six gallons of water, but on the 12th there was a swarm of larvæ and recent sets extending even to the leaves. Growth had stopped at this time, and as the tree was not too large and had a good coating of scale, it was selected as one of the two to be covered for breeding *Chilocorus similis*, the Chinese lady-bird, that feeds on the pernicious scale. The screen cage, 4 x 4 x 7 feet, was put in place July 22d, and after that the tree was left to itself. The observations on the Coccinellids are elsewhere recorded.

October 22d, foliage was beginning to drop, the tree seemed to be

in very fair condition, all things considered, and it was certainly, to all appearances, just as scaly as ever—but not more so.

TREE 33—*Dwarf Duchesse.* Was cut only enough to keep it symmetrical, and on March 31st was moving well forward in development. Leaf buds were pointing out, blossom clusters were swollen and there was a little scale all over the tree. April 22d, the flowers began to open; on the 25th was in full bloom, and on the 28th petals began to drop. May 1st, was in full foliage and almost out of bloom. Less than a dozen fruits set, and all of these withered and dropped by June 1st. All growth had stopped June 18th, but a new growth started July 4th, when there was a very little scale and some blister mite. August 12th, the scale had taken a new start and began to cover things, even unto the leaves; so, on September 1st, I included this in the list of trees sprayed with whale-oil soap, one pound in two and one-half gallons of water. No harm was done to the tree, while the moving and recently-set brood was wiped out; but on the 8th another swarm of larvæ began to appear.

October 22d, was yet in practically full foliage, scaly all over—at a few points even coated—but, on the whole, not a seriously-infested tree.

TREE 34—*Lawrence Pear.* Is a scrub; scaly, scurfy and everything else that is bad—really not worth keeping as a tree.

Made a start April 23d, and was in full foliage May 1st. Growth stopped June 18th, and the scale began breeding as a compensation. The insects did not multiply greatly, for some reason, and up to September 1st there was no bad infestation. On that date, as there were some moving larvæ, I sprayed with whale-oil soap, one pound in two and one-half gallons of water. This killed off the young, and on the 8th nothing was seen of larvæ or recent sets.

October 22d, the foliage was yet complete, the old wood was moderately scaly, the new wood practically clean. A sinuate borer is in one of the smaller branches.

TREE 35—*Japanese Walnut.* No pruning was done, and the tree had a few, scattered scales when the season opened. The terminal leaf buds began opening April 23d. May 7th, foliage was well advanced, with blossoms about ready to open. May 12th, was in bloom, and on the 18th the flowers were all gone. Several clusters set, but only two nuts came to maturity. May 23d, whitewashed the trunk, and on June 18th the lime was practically all off. The scales noted

in spring seemed to disappear by midsummer and no more were noted until the late examination in October. On the 22d of that month more than half the foliage was off, the tree seemed in excellent condition and there was a scattering of half-grown scales on the trunk. All were of about the same size, and, apparently, there had been no breeding.

TREE 36—*Apple* (variety unknown). Was trimmed in a little, and at the opening of the season was scaly throughout, but not dangerously so. Not until May 7th did any leaf buds begin to open, and not until after June 1st was it in full foliage. Scale breeding was in full swing June 18th, and on the 24th sprayed with agricultural soap. Not much result was observed from this, and on July 4th the tree was again swarming with larvæ. On the 5th sprayed with black insecticide soap, one pound in six gallons of water, with the usual lack of good results. July 22d, the tree was very scaly and was covered with a wire cage, 4 x 5 x 8 feet, into which were introduced a dozen *Chilocorus similis*, received from the United States Department of Agriculture. No other experiments were made with this tree, and it was left to take care of itself. October 2d, there was a large number of colonies of woolly plant lice—more than the tree had ever had before. On the 22d it was in full foliage, scaly as ever and with more woolly lice than all the other trees combined. The surface of the ground was full of long grass and offered excellent opportunity for hiding places for the *Chilocorus*.

TREE 37—*Spaulding Plum*. The new shoots were cut back one-half during the winter, but no cutting out was done. Some scales were on all parts of the tree, but not enough to hurt anywhere and very little on the new wood. The tree started unevenly, as usual; some buds showing white, in lower part of tree, April 18th, while the upper shoots were yet entirely bare. April 25th, was in full bloom, and on the 28th the flowers began to drop. May 1st, it was leafing out to the tips and all the bloom was gone. May 7th, applied Calcothion to the trunk and lower branches, avoiding foliage so far as possible. No injury was done, and on the 23d there was a small set of fruit on the lower branches. No scale breeding was noted until after July 4th, at which date not a sound fruit was left. August 12th, all the fruit was gone—rot, curculio, drop and otherwise—and not a single example ripened normally. Very little scale anywhere on the tree and none where the lime wash had come.

October 22d, the foliage began to thin out at the tips of the shoots, there was a mere scattering of scales at the joints and the tree had made an excellent growth.

TREE 38—*Baldwin Apple.* Was a little cut back during the winter and a few interferences were removed. The tree was very scaly and, outwardly, most of it was alive. It started, irregularly, April 18th, and was hardly in full foliage May 1st, when I applied Calcothion on the trunk, branches and in the interior of the tree. Foliage was hit freely, but I did not make the spraying general. May 4th, most of the leaves hit by the spray looked burned and lifeless. On the 7th again applied Calcothion, avoiding foliage as much as possible. May 18th, all the leaves hit by the spray were gone, and on the trunk and branches the wash still formed a good coating a month later, when the scale began to breed. July 13th, the tree was doing well, no live scale was on trunk and in lower part of tree, but plenty of it on last year's growth. No larvæ or recent sets were noted. A month later growth had stopped and leaf-hopper injury became apparent. There was only a little scale and that was well scattered. As web-worms were becoming obvious, sprayed, August 15th, with arsenate of lead, one pound in ten gallons of water. This application was duplicated on the 19th, because colonies were seen starting well up in the tree, and thereafter no more were noted.

October 22d, the tree was in good condition and yet in full foliage. There was practically no scale on the trunk and larger branches, but quite a bit on some of the outer shoots.

TREE 39—*Fallowater Apple.* Only enough cutting was done to give the tree a symmetrical top. Plenty of scale—much of it dead—but some branches very much encrusted. April 18th, the tree made an irregular start, and May 1st it was in tolerably full foliage, with several blossom clusters, on which no fruits set. May 7th, Calcothion was applied to the trunk only, and by June 1st very little of it remained. June 11th, sprayed with arsenate of lead, which checked web-worms as they came on. Scale breeding began on the 18th, and on July 4th the tree was in very poor condition; some shoots were dying, all others had stopped growth and scale was everywhere. July 5th, sprayed with black insecticide soap, one pound in six gallons of water. There seemed to be less active scale on the 13th, and on the 15th sprayed again, using one pound of the soap in two gallons of water. On the 28th another application, of the same strength,

was made, and fully a gallon of the mixture was applied. August 12th, some twigs were dying and there was a new brood of larvæ moving. On the 19th sprayed with arsenate of lead, to kill web-worms of the second brood. On the 21st the tree was swarming with larvæ and recent sets, but there was comparatively little on the new growth.

October 22d, the foliage was yet quite complete, except on some very scaly shoots. The upper part of the tree is very scaly and some branches are simply encrusted. *Pentilia* is very abundant on this tree.

I have always expected this tree to die. It was a poor stick from the beginning, and since February, 1899, it has had no general winter treatment. It has become very badly infested year after year and has always received late summer applications enough to carry it safely through until the season following. I have not cut it out simply because I am curious to see how much a tree like this will really stand.

TREE 40—*Lincoln Coreless Pear.* The long shoots were cut back a little, but no other pruning was done, and when the season opened there was a little scale all over the tree. Leaf buds began to open April 23d, and May 1st it was in full foliage. June 18th, scale breeding began with a rush; a colony of web-worms was destroyed, and on July 4th scales were on the leaves, as well as on the new wood. No spraying was done on this tree and nests of web-worms were crushed as they were noticed until August 19th. Then they became so numerous that I applied arsenate of lead, one pound to ten gallons, and had no further trouble.

October 22d, the foliage began to drop and the tree was just about as scaly as usual at the same season. On the old shoots the mature scales were beginning to drop off.

TREE 41—*Greensborough Peach.* The Elberta peach that occupied this place was so badly broken by the February sleet storm that it was taken out and replaced, in March, by one of the above variety, cut to a straight, four-foot stick. It started April 23d and grew well throughout the season. Scales were first seen August 12th, and from these the trunk became pretty well covered by October 22d. The foliage was yet complete, but stripped readily.

TREE 42—*Elberta Peach.* The tree was cut back during the winter so as to leave buds well distributed for a good crop. At the beginning of the season the tree was pretty evenly scaly, but no winter applica-

tion had been made. The first blossoms began to open April 20th; on the 23d it was in full bloom, and by May 7th it was in full foliage, with the flowers all gone. May 12th, sprayed with whitewash until the trunk and old branches were white. Used Nixon pump and Bordeaux nozzle. Avoided the outside foliage, but made no attempt to save the inner leaves. A rain during the night made the coating imperfect next day, but on the whole it stuck well, being yet obvious a month later and not all gone two months later. The inside shoots hit by the wash dried up and dropped, and not until the middle of June did any new shoots start to fill the gap. Scale breeding began June 18th and continued practically unchecked throughout the season, getting on the leaves and branches everywhere, but not much on the trunk, which was rough and hard. A little got on the fruit, but not enough to injure it. July 5th, sprayed with black insecticide soap, one pound in about six gallons of water, but without any apparent benefit.

October 22d, foliage was beginning to drop. There had not been much growth during the season and the fruit buds are badly placed for next year's crop. This is due in part to the killing of the inside shoots, which were not replaced by fruit-bearing shoots later in the season. On the area that had been lime-covered there was not much scale, but, outwardly, some of the shoots and branches are pretty well incrusted.

There was a pretty good set of fruit, and when it developed there proved to be as much as the tree could reasonably carry. It began to color up in August and was fully colored by the 24th. Up to September 1st fully a basket of fine fruit had been taken off, and by the 8th nearly another basket had been secured, all very large and good.

TREE 43—*Early Richmond Cherry.* This tree was ready to start March 31st, and blossoms began to open April 22d. Was in full bloom April 25th and out of bloom May 1st. A rather small set of fruit was made, which began coloring June 1st, and was at once attacked by robins, who left not a single cherry to come to maturity. Not very much growth was made during the season, and on October 22d all the foliage was yet present, with practically no scale anywhere on either trunk or branches.

TREE 44—*Elberta Peach.* In pruning, cut out very little fruit-bearing wood and left buds for a heavy crop. There was plenty of scale on the tree and much of it was alive. A start was made April 16th,

the first flowers opened on the 20th, was in full bloom on the 23d, dropping petals on the 28th and all out of bloom, but in full leaf May 7th. On that day applied Calcothion to the trunk and base of branches. June 1st, practically all the wash was off; the young foliage where hit was killed, but the older leaves seemed to remain unharmed. Scale breeding began June 18th, but the first brood seemed light and there was not much set up to August 12th, when the fruit began to get a trace of color. On the 24th the peaches were fully colored, of very good size, and there were quite as many as the tree should have. Up to September 1st fully a basket of extra fine fruit was taken off, and by the 8th almost as much more was obtained.

October 22d, was yet in good foliage, hardly more scaly than at the beginning of the season, and with a light set of fruit-bearing wood for 1903.

TREE 45—*Black Tartarian Cherry.* Was removed to the place previously occupied by a peach—No. 48. No other tree was set where this was taken out.

TREE 46—*Mountain Rose Peach.* Several branches were broken in the February sleet storm and these were removed. At the same time, trimmed so as to leave wood for a good set of fruit. There was plenty of scale everywhere, and in that respect it was the worst-looking tree on the place. It started April 18th; the first flowers opened on the 21st; was in full bloom on the 25th; dropping its petals May 1st; out of bloom and in full foliage May 7th. On the 12th sprayed with whitewash until the trunk and old branches were white; avoided the outside foliage, but made no attempt to save inner leaves. A heavy rain during the night made the lime coating imperfect at once, but some of it stuck until the middle of July. The leaves and shoots were killed where hit by the lime, but the older foliage was not harmed. Scale breeding began June 18th, at which date, also, new shoots began making on the sprayed area. The fruit moved slowly until the middle of July, up to which time the scale, also, had not made much progress. Fruit began to color August 12th, and the first fully-ripe examples were picked on the 22d. Thereafter, nntil September 1st, some specimens were picked every day and a very decent crop of fine fruit was secured. The tree improved immensely in appearance after midsummer, and on October 22d was yet in full foliage and excellent general condition. The inside growth had developed well, a good set of fruit buds had been made and, altogether, the tree was in much better shape than at the beginning of the sea-

son. There was scale all over the tree, but not much in any one place, while the trunk was so rough and scarred that there was little chance for the insect to maintain itself there.

TREE 47—*Greensborough Peach.* This is a clean, five-foot stick, set in March to replace a Triumph, taken out because of its tendency to rot. It started April 23d, grew well during the season and was yet in full foliage October 22d. No scales were found until August 12th, but on October 22d there was a scattering everywhere.

TREE 48—*Black Tartarian Cherry.* This was tree No. 45 until, in the fall of 1901, it was moved to replace No. 48, taken out because of its tendency to rot. No trimming was done, and no appearance of harm from moving was obvious until after the tree had blossomed. Then, after the fruits set, they wilted and dropped. The foliage remained complete throughout the season, but made no progress, being exactly in the same condition October 22d that it was on May 7th. No scale on the tree at any time.

It will be noted, on looking over this record, that none of the trees had a radical treatment during the winter of 1901–1902. Some of them were quite badly enough infested to call for such treatment, but it was decided to let them run their chances. On the whole, the result is interesting and instructive, since not one tree was killed or even severely injured by the neglect, while some are in at least as good condition as they were last year at the same date. The late day when the Calcothion was received made it impossible to apply it to any one tree so completely as to test its power of really clearing a tree; but, so far as it was used, it was one of the most effective preparations tried. No experiments were made with oils. This branch of the investigation may now be safely left to the fruit-growers, who will decide which of the methods advised will best meet their individual needs. In another portion of this Report the lime, salt and sulphur wash and crude oil are more specifically referred to.

THE PERIODICAL CICADA.

Cicada septendecim Linn.

The occurrence of this insect, commonly known as the seventeen-year locust, is always interesting, though its habits are now so well known that no lengthy account need be given here.

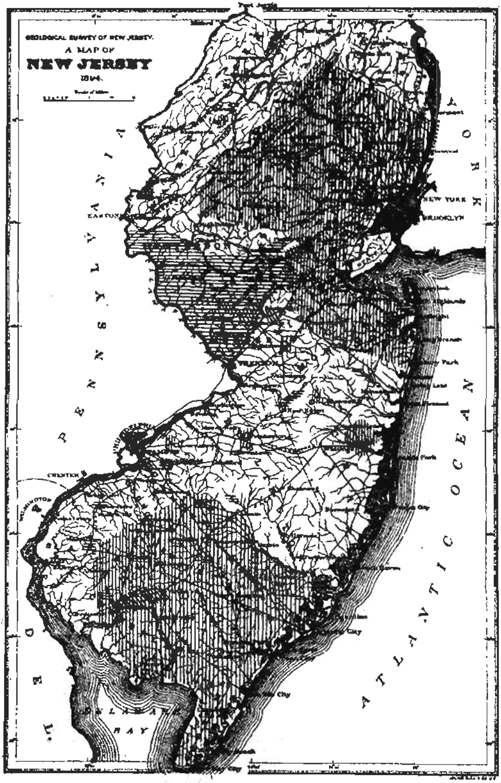

Fig. 1.

Map showing the distribution of the main broods of the Periodical Cicada. Horizontal lines, east and west, denote brood XXII (1902); vertical lines, north and south, denote brood XII (1894); lines sloping from southeast to northwest denote brood XVII (1898); lines sloping from

The first appearance of this Cicada noted by me in New Jersey was in 1889, when brood VIII. was recorded in the report for that year. At that time, also, I compiled from published records a list of the broods occurring in this State and gave their distribution so far as then known. The broods were VIII. (1889), XII. (1894), XVII. (1898) and XXII. (1902). It will be noted that all the broods then listed have since appeared, and all of them on time, in the general area designated. In the reports for 1889, 1894 and 1898 the distribution of the various earlier broods is given, and it may not be uninteresting to review briefly these localities before recording in detail the appearance of the present year.

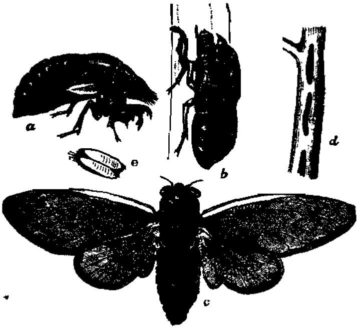

Fig. 2.
The Periodical Cicada: *a, b*, pupa shells from which the imago has emerged; *c*, imago; *d*, punctures in which the eggs are laid; *e*, eggs enlarged. After Riley.

Brood VIII. had not been positively recorded from New Jersey prior to 1889; in that year I received it from isolated localities in Bergen, Mercer, Burlington and Gloucester counties. The brood is a small one, the area of its appearance is limited in well-settled regions and it is doubtful whether in 1906 it will be noticed at all.

Brood XII., appearing in 1894, covered the entire State in so far that there was no county that did not have at least one colony; but the stronghold was in the northeastern section, from the second range of the Watchung Mountains to the Hudson. In the southern counties

the colonies were much scattered, and so they were in the Delaware counties, only one occurring at all close to the Delaware river. The brood occurring this year (1902) is strong in the northern Delaware region and almost wanting in the northeastern area, where brood XII. was most abundant.

Brood XVII., for 1898, rested upon a single record from Essex county; but in that year my correspondents reported colonies from Bergen, Essex, Morris, Passaic, Union, Somerset, Middlesex, Mercer and Cumberland counties, none of them very extensive or very numerous and some so located that the chances are against their future reappearance.

Brood XXII. almost matches brood XII., in New Jersey, so far as area covered and numbers are concerned, but is somewhat inferior in both respects. It was well recorded in 1885, though not by me, and I was anxious to get it as fully delimited as possible. This meant correspondents from all sections of the State, and to secure these I organized a campaign, as follows:

The Organization.

To call the attention of farmers and fruit growers to the probability of the insects' appearance in certain districts, the following circular was sent to the entire bulletin list, comprising some eleven thousand farmers from all parts of the State, and this was reprinted quite generally by the newspapers, in whole or in part:

NEW JERSEY AGRICULTURAL EXPERIMENT STATIONS.

THE PERIODICAL CICADA.

A Word of Caution to Orchardists.

Brood XXII. of the Periodical Cicada or, as it is better known, the seventeen-year locust, is due to appear in New Jersey in 1902. This brood is one of the most numerous occurring in the State, and was recorded as being injurious in 1885, the date of its last appearance in Burlington, Camden, Mercer, Middlesex, Monmouth, Passaic, Morris, Warren, Sussex, Somerset and Hunterdon counties. Its exact limits have not been defined; therefore it behooves fruit growers in all of these counties to be on their guard.

A life history of the insect is given in Bulletin No. 95, some copies of which are yet available, and in the Annual Report for 1894.

To avoid injury, growers in the sections above named are advised not to set out young orchards either in the fall of 1901 or spring of 1902 if they can avoid it. If they do set, do not prune too closely; *leave as many shoots and branches as possible in which the insects* may lay their eggs without harm to the tree itself. These branches may then be trimmed out early in July, when all danger is past.

Do not trim fruit or other trees or shrubs too closely, and, where not absolutely required, do no trimming at all. Do no budding or grafting either this fall or next spring, as growing buds and grafts are especially apt to be injured. The attention of nurserymen is particularly called to this matter, that they may adopt such measures as seem advisable to them. Where sparrows occur in large numbers, the danger of great injury is much reduced. This is intended as a warning merely, and not as a bulletin of information.

JOHN B. SMITH,
Entomologist.

NEW BRUNSWICK, N. J., September 4th, 1901.

In the first number of the Crop Bulletin for 1902, issued April 30th, the following notice appeared:

"The Periodical Cicada is expected to appear in several counties of the State; but the distribution in these counties is not well known. It is a matter of importance to learn the exact localities where the

insect occurs. Professor Smith asks that crop correspondents note in their reports the appearance of the insect in their respective localities. The insects will probably emerge from the ground during the last week in May, and it is important that the record be sent in as soon as the species is actually seen or heard."

The number or correspondents affected by this notice is 127, and they are scattered throughout the State, so as to reach all sorts of conditions of crop and climate.

A circular-letter, inclosing a copy of the circular already quoted, was sent to all the Insect Commissioners, under date of May 29th, 1902. The following is a copy of the letter, and it went to sixty-five persons, scattered throughout the State:

DEAR SIR—I send you inclosed herewith a copy of the circular that was sent out generally last fall. Won't you please make an effort to ascertain whether the Cicada makes its appearance in your vicinity, and if so, let me hear from you as soon as you have made certain of the fact. Yours, etc.,

JOHN B. SMITH,
State Entomologist.

In my travels through the State I kept a lookout for Cicada appearances and questioned people from all sorts of places. In this way I personally reached every county in the State, and I have traveled to the end of almost every branch of the West Jersey and Seashore, Atlantic City, and Pennsylvania railroads running south and east from Camden. I have crossed the State on the Delaware, Lackawanna and Western, Lehigh Valley, Central Railroad of New Jersey and Pennsylvania railroad. On the Erie I have run north almost to the State line, and I have visited almost every shore point between the Highlands and Cape May. While it is possihle, therefore, that I have missed local occurrences, it is unlikely that any large colonies escaped being listed.

It should be added that some of the leading agricultural papers asked for records of the insects' appearance, and these papers go to *every township in the State.*

Finally, Mr. C. L. Marlatt kindly sent me all the New Jersey records received in the Division of Entomology of the United States Department of Agriculture.

Combining the results from all these sources, the following distribution has been established:

Distribution.

The northernmost point for which I have any record is Roxburg, Warren county, whence they were reported by Mr. J. D. Vannatta in the Crop Bulletin for June 3d; their disappearance was chronicled, in the same way, on the 24th of that month. In response to a personal letter, Mr. Vannatta wrote that he had been over considerable territory in his township and found that in some localities the Cicadas were very numerous. Along the line of the Belvidere Division of the Pennsylvania railroad an area of infestation began north of Riegelsville, and this extended back from the river as far as I could see. Where the hills opened the forests of the second ridge could be seen to be as badly cut as those of the first. Just how far back this area extended I could not see; it ran north to Carpenterville, but was broken at the edges and did not reach Phillipsburg along the railroad. In fact, I ran north to Manunka Chunk, along the river and crossed the county on the Delaware, Lackawanna and Western railroad, without seeing anything more of the insect. Starting east from Phillipsburg, on the Central railroad, there is an infested area, south of the track, between Springtown and Bloomsbury, but this did not seem to be very extensive. On the Lehigh Valley railroad the insects were noted between Kennedy and Bloomsbury, a large area extending on both sides of the track for more than a mile, to the second ridge from the river. Altogether, it may be said that the southwestern corner of Warren county, south of the Central Railroad of New Jersey and along the Delaware river, is pretty well covered by this brood.

Running south along the Delaware, the Warren county area of infestation extends into Hunterdon county and for its full length. It is broken, of course, at several points, notably at towns and settled areas, but practically the ridge back of the river is all cut by Cicada. Between Riegelsville and Milford is a very large colony, which, where the hills open between Milford and Holland, could be seen to extend far back into the interior. There is a little break at Milford, but south of that cut twigs became evident once more. Then there was quite a little break to Tumble Falls, whence the infested area continued along the ridge to Raven Rock. Then there was a break to Stockton, where another colony extended to Lambertville, and south of it to the county line.

Continuing on the Lehigh Valley railroad, east from Bloomsbury into Hunterdon county, a colony was seen on the ridge before reaching West Portal. It seemed to be rather scattering, but extended sonth as far as I could see. Another colony was in a bit of woods between Pattenburg and Jutland, extending well toward the latter place on both sides of the track. Nothing further was seen from the railroad, but reports received continue the colonies along its line to Three Bridges. In a ride over the Flemington branch of the Belvidere Division signs of Cicada were seen at Mt. Airy, Boss' Road and Muirhead. Flemington was several times reported. Driving from Flemington to Sergeantsville, a large colony was found near the latter point. Aside from these personal observations, the insects were reported from Hunterdon county in the Crop Bulletin as follows: May 27th, Sergeantsville, by Mr. J. M. Hartpence; June 3d, Flemington, by Mr. H. E. Deats; Frenchtown, by Mr. J. W. Lequear; Kingwood, by Mr. John Bellis; June 24th, Pittstown, reported as injuring trees by Mr. L. B. Hann. July 15th, their disappearance, without injury, was announced from Rowland's Mills by Mr. J. Q. Hoagland. The earliest date of appearance is May 21st, followed closely by May 23d, 24th and 25th, which latter seems to have been the time when they first began to come out in numbers.

Other reports from this area came from Mr. John T. Cox, Readington, under date of Juue 4th; from Rev. F. J. Tomlinson, Pittstown, under date June 5th, and from Mr. John Bellis, Kingwood, under date June 7th. Mr. Cox reports the first examples for June 2d. Mr. Bellis gives June 5th as the date when he first heard them. Mr. Tomlinson wrote me at some length: "The vanguard began to show themselves at the surface on Tuesday, May 27th, bnt I did not see any come out voluntarily until Thnrsday night. Our little chickens did bring many out of their holes on Tuesday and Wednesday. The weather was cool and disagreeable and not to the liking of the Cicada. They seemed like impatient children, waiting favorable weather to go out. They would come to the surface and look out and then back down in their canal; but our little chickens discovered them and went locust hunting—when they saw a head in the hole they went for it, helped the owner out of it and had great fun dividing the carcass. The chickens—large and small—cats, sparrows and robins are all fond of them, but there seems to be too many for all of them. They began to come up in great numbers Friday night, May 30th."

The appearance of the woodlands over the infested area and the general tone of the reports indicate that the insects were very numerous. I was informed that some orchards in the Flemington district had suffered considerably, and in the *American Agriculturist* for July 19th there is a note from Kingwood, that "Young orchards have suffered badly from locusts. Chestnut trees show many dead branches, testifying to the destructiveness of the winged invaders." Further notes on this point appear later.

Generally speaking, the southern half of Hunterdon county may be said to have been infested and, probably, specimens extended over that entire area. North of the main line of the Central railroad I have no affirmative records, and, so far as my own observations go there is no appearance of their occurrence. It may he noted in this connection that brood VIII. occurred only in the northern part of this county, whence I have no records this year.

South of Hunterdon is Mercer county, where the next largest swarms occurred. Referring again, first, to the Crop Bulletin, Mr. E. R. Cook reported, May 27th, that "the Periodical Cicada appeared in small numbers in Ewing township." The same gentleman, under date of June 10th, writes from Trenton to the same effect, while Mr. James F. Herbert, at Trenton Jnction, reports the insects in large numbers.

June 3d, Mr. John M. Dalrymple, Hopewell, wrote: "The Cicada has made its appearance in this vicinity in very large numbers. * * * My apple orchards are full of them; also, my shade trees about my house. There are, also, immense quantities of them in the woods, less than a mile from my place. * * * I think there are now more of them than I remember in any former year."

At Princeton the insects appeared in such numbers that on June 3d Mr. J. H. Hale was able to send me a quart of specimens. Mr. Dickerson made two trips to that place later, and found the insects plentiful, but not extending to Princeton Junction.

In the course of a visit to Hightstown, June 25th, I learned that the Cicada appeared in small numbers at and very near that place, gradually becoming more plentiful in the Princeton direction. Sparrows and other enemies had cleaned up the few that appeared, and it is doubtful whether they have left sufficient for a future reappearance.

Along the main line of the Pennsylvania railroad a large area of cut twigs was observable near Lawrence Station; at several points between Trenton and Lawrence a few cut twigs were noticed, but

near the latter place, on both sides of the road, the injury became *very obvious. Between Lawrence and Princeton Junction there is* one oak woods which seemed as if every tip on each tree were killed. A few cut twigs were seen near Princeton Junction, but between that point and New Brunswick no cutting that could be safely charged to Cicada was observed. It seems, thus, that in Mercer county the insects were pretty generally distributed, except in the extreme south, and that there was very little south of the line of the Pennsylvania railroad. The largest colonies are the southern continuations of the Hunterdon groups.

Somerset county adjoins Hunterdon on the east and Mercer on the north, and several colonies are reported. In the Crop Bulletin for June 17th, Mr. Jacob Wyckoff states that the first Cicada appeared at Middlebush on the 12th, while Mr. D. S. Campbell heard the first specimen at Martinsville on the 13th. In the issue for June 24th, Mr. A. F. Randolph states that at South Bound Brook the "English sparrows destroy locusts as fast as they appear."

June 5th, Mr. Wm. H. Skillman wrote me from Rocky Hill that the Cicadas had appeared in his vicinity, and "have brought all their relations with them." Mr. Dickerson made two trips to this place to collect specimens and secure examples of the chimneys that occurred there. At this place was the strongest colony in the county, and it petered out slowly, a few extending nearly to Franklin Park. At a farmers' meeting at the latter place, June 24th, I asked those assembled concerning the insect, and only toward Rocky Hill had any been noted. Mr. E. S. Davis, of the Class of '02, informed me that specimens taken in Bound Brook had been brought to him, and that they were said to be more abundant at Raritan. From Somerville they were reported by Mr. Peter Hardcastle, and, later, Mr. Arthur P. Sutphen informed me that a few specimens had been observed northwardly. From Neshanic came a report of a few specimens through Mr. James L. Garabrandt, of the Class of '01, and a student in my course. This joins the colony reported from Three Bridges, and indicates a scattered infestation along the lines of both the Lehigh Valley and Central Railroad of New Jersey west from Bound Brook. From Bound Brook to Somerville the sparrows probably took care of all that appeared. Harlingen and Kingston are added from Mr. Marlatt's records, and are extensions of the Rocky Hill colony. There is no record north of Martinsville, except a negative one from Basking Ridge. There are a number of good farming communities

in this northern section and I think it certain that I should have heard of it had the insects appeared in any number. Altogether, Somerset county was not very heavily visited except at one point.

Middlesex county lies just east of Somerset and Mercer, and, while the insects have come right up to the boundaries, I have few positive records of their occurrence within its borders. Under date of June 5th, Mr. Wm. Woerner recorded hearing the first Cicada at Piscatawaytown, and Mr. Woerner certainly knows both the insect and its song. June 12th, Mr. Dickerson covered the territory along the trolley line between New Brunswick and Metuchen, neither seeing nor hearing the insects. It is probable, therefore, that only stragglers occurred and that these were cared for by the sparrows. It is more than likely, also, that near Bound Brook, on the Raritan, a few examples occurred, but hardly any real colony. I have crossed Middlesex county by rail in every direction since July 1st without seeing anything of Cicada work. Mr. Marlatt has a record from Deans, where they are said to have occurred by the million, but I saw no traces of them myself, nor were they reported to me from that point. Late in October, while closely examining the trees in the Experiment Orchard, I found one twig on one apple tree which contained the characteristic punctures, so one specimen at least was very close to me for a time without my knowledge.

In Monmouth county a single colony appeared at the Highlands of Navesink, and so far was this out of the general course of the brood, that I questioned Mr. J. H. Willey, of Keyport, as to the correctness of his information. He replied, under date of July 5th, and insisted upon the correctness of his information. "I have seen several people from there and they all tell the same story." He adds that the insects were very numerous, and that seventeen years ago he saw them near Keyport, where this year they were not seen by him. Subsequently this report was confirmed by a number of persons, and the *Long Branch Record,* under date of June 13th, reported millions at Locust Point, near Oceanic, and in the hills leading to the Highlands of Navesink. It is curious that there should be a colony so far detached, but not more so, really, than some other of the occurrences of this brood.

South of Monmouth is Ocean county and almost on the line between Ocean and Burlington counties is New Egypt, whence Dr. G. W. Chamberlain reports a colony that extends into both counties. He wrote, under date of June 2d: "I have been making careful in-

quiry and learn that they were numerous from Collier's Mill across by old Zion church and north and east toward Prospertown (Ocean county). Also learn that between Jacobstown and Ellisdale (Burlington county) there was a colony." There is no other record for Ocean county, and I have crossed it on every line of railroad running through it without seeing any trace of injury to woodland.

From Burlington there is one other record, at Indian Mills, by Mr. Henry Wright. He wrote me, under date of July 1st, replying to my questions: "As to your inquiry about the Cicada, or seventeen-year locust, would say that they have been quite numerous only in certain localities—in Shamong township, in the vicinity of Naylor's Corner and what is called Forked Bridge Neck road. At each of these places there is from one to two hundred acres of young timber and they have been very numerous in this timber. They were also in the same locality seventeen years ago. I have not heard or seen any on fruit trees so far, and the last heavy rains have put them in shelter, somewhere." I have so many correspondents in Burlington county, that it is hardly probable that any other large colony could exist without my hearing it. I saw no traces of any in the woodland along the roads traveled by me.

Camden county, also, gives one record. Mr. Samuel Wood, Haddonfield, writes, under date of June 5th: "The Cicadas made their appearance on May 24th in the same locality where they did so much damage before (in Delaware township), and as yet have seen none in Haddon township. I was around the district where they are this morning; they were making lots of noise, but do not appear to be doing much damage."

Salem county has two colonies, not very widely separated. The first record is from Mr. Woodnut Pettit, of Salem, under date of May 31st: "Yes, we have lots of them, if you go to the right place to find them—that is, in the timber land. This is the fourth time I have witnessed their visitation—1851, 1868, 1885 and now. I never knew them to do any damage to nursery or orchard trees where the young trees had been set or planted on lands that were not occupied *as forest or timber land seventeen years previous. If at that time* they were, and the forest had been cut off since, why, of course, when they came to the surface they would immediately alight on the orchard trees and commence reproduction, etc. About two miles east from my farm during the past fifty years there has been a large tract

of timber land, which is, unfortunately, gradually becoming exterminated. This tract at each visitation of the Cicada has been infested with millions of the insects and, with an east wind, you can hear them sing all day; yet, notwithstanding this fact, I have never, with the possible exception of 1851, been able to collect half a dozen specimens on the farm, and don't expect to find any this year, either. I am satisfied that, if they have satisfactory feeding and breeding places when they arrive, they will not migrate therefrom."

I have quoted Mr. Pettit's letter very fully, because, not only has he observed an unusual number of broods, but he has hit very closely the conditions under which injury is likely to occur.

June 6th, when sending specimens, Mr. Pettit wrote: "I have seen them to-day so thick that small twigs would bend over with the weight. Not having had any rain here for some weeks sufficient to fill the holes they made in coming out of the ground, they were very plainly seen wherever you looked for them—hardly a square foot of ground but what has been punctured by them."

June 7th, Mr. M. D. Dickinson wrote that the "Cicada made their appearance near Yorktown, in Salem county, about three miles from Woodstown, and that they were very numerous." On the 10th the Crop Bulletin contained a report that the insects had appeared at Woodstown, and this closes my records from Salem.

Gloucester county is just north of Salem, and, while I have no records myself, Mr. Marlatt sends references to newspaper reports of their occurrence at and near Swedesboro and in the woods between Harrisonville and Swedesboro. This is in line with the Salem colonies and extends the range a little farther north. I saw nothing of the insects near Paulsboro nor anywhere along the line of the Penns Grove branch of the West Jersey railroad. The county is tolerably well settled, and had the insects appeared at all generally, I believe I should have heard of it. I have crossed the county on every line of railroad that runs through it and saw nothing of Cicada work from the cars.

Cumberland county has one colony, near Shiloh, in the same general territory with the Salem areas of infestation. This colony was first reported in the Crop Bulletin for June 10th, by Cora M. Sheppard. It was next referred to, under date of June 13th, by Mr. Thomas Hunt, who wrote from Greenwich that the insects had not been seen or heard in his township. "The nearest record is at Shiloh, five miles distant."

In a question of distribution, particularly of an insect likely to prove injurious, it is often as important to know where not to expect it. Hence, negative evidence has been as diligently sought for as was that which actually recorded the presence of the insect.

Based upon such evidence, it is quite certain that the Cicada occurs neither in Hudson nor in Essex counties. There are numerous collectors of insects in both, and it is almost impossible that the insects could have occurred and escaped notice. In Hudson county areas of possible occurrence are limited, and I feel very certain that no specimens were present. In Essex county the wooded slopes of the Watchung or Orange mountains would seem to offer excellent opportunities for the insects; but this a stronghold of brood XII., which appeared in 1894, and the same men who recorded that brood for me so thoroughly reported positively that no trace of the iusects was found this year. These reporters include members of the Newark and New York Entomological Societies, who would almost certainly have noted the species had it occurred, and all these made negative statements. I may add that I have myself covered a considerable part of this county without finding any trace of the insects.

For Bergen and Union counties almost the same may be said. Bergen county has a number of excellent reporters, who kept a sharp lookout, and nowhere was there any appearance of the insect. In a few cases in Bergen county young orchards had been left untrimmed, in accordance with my suggestions; hence, the owners had a very strong interest in the matter, that made them anxious for any information, positive or negative.

In Union county there are a number of good observers, who would have, almost certainly, noticed the insect had it occurred, and I personally crossed the county in several directions during the season without either seeing or hearing of it. It should be noted that none of the four counties mentioned was included in the circular sent out in September, 1901, as having been covered by previous records.

Passaic and Sussex counties are blanks in my record, and so is Morris. All three of these are mentioned in my circular as having been referred to in previous publications concerning this brood.

Passaic and Sussex counties are well north of any definite reports concerning this brood. For Passaic I have nothing, one way or the other; but parts of the county are so well settled that the insects conld not have escaped notice had they appeared. Brood VIII. is well recorded from this county.

In Sussex I have one negative report from Deckertown (Sussex). Mr. Samuel A. Miller reports none appearing and that none are due. I saw no signs of any on the shores of Lake Hopatcong nor on the road to Edison; but there is a considerable area in this county that is not well covered and it is not improbable that colonies may exist on the wooded hillsides.

Morris county is almost in the track of the brood across the State, but all my records are negative. Such records come from Morristown and Chester (Dickerson), and I personally visited Morristown on two occasions, when any appearance of Cicada work would certainly have attracted my attention. There is no appearance of injury to woodland along the lines of either the Delaware, Lackawanna and Western or the Central Railroad of New Jersey, through this county. Mr. Marlatt sends me a record of their occurrence near Boonton, which is farther north than any other in the State, and which I have not been able to verify.*

Briefly stated, if we draw a straight line across the map of the State from Rahway to Belvidere, there is no record of Cicada north of that line.

Neither Atlantic nor Cape May counties record the brood and neither is mentioned in my circular. In Atlantic county, Mr. L. Monfort, of Hammonton, and Mr. Henry Pfeiffer, of Cologne, both report that they could hear of no Cicadas after diligent inquiry. Brood VIII. is the one known there. Personally, I have crossed the county on the West Jersey and Seashore and Atlantic City railroad to Atlantic City, and from Winslow to Tuckahoe, without noting traces of injury in the forest. It is fair to assume that the insects did not occur here. Cape May county sends no records of any kind, and I have traveled the county on both the railroads to Cape May City without noting any signs. During the time spent along shore on the mosquito investigation I met many persons from this county who would have been able to inform me of the appearance of the insects had they occurred. Woodbine suffered seriously in 1894, bnt I was positively assured by a resident that nothing was seen of the Cicada this year.

I think it is fair to claim from the above records, positive and negative, the distribution shown in the map printed herewith. The map also shows the distribution of the other broods and gives a fair picture of the overlapping of colonies in some localities.

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* The editor of the *Boonton Weekly Bulletin* states positively that the insects did not occur at or near that place.

A New Classification of Broods.

Late in 1898 Mr. C. L. Marlatt, of the Division of Entomology of the United States Department of Agriculture, after a careful study of all the records, proposed a new enumeration of the broods, recognizing the existence of some that had not been previously defined. One of these new broods, under XV. (1890), occurs in New Jersey in small numbers. Several of the members of the Newark Entomological Society brought me specimens taken in Essex county, and I noted the species at Anglesea, Cape May county. It was supposed at that time that these were delayed members of the brood VIII., and no effort was made to learn if the insects occurred elsewhere. Mr. Marlatt, however, found records from New York and North Carolina, which indicate a distinct brood, whose colonies are widely scattered.

As rearranged by Mr. Marlatt, the New Jersey broods are—II., last occurring in 1894 (XII. of the old style); VI., last occurring in 1898 (XVII. of the old style); X., occurring during the present year (XXII. of the old style); XIV., last occurring in 1889 (VIII. of the old style), and XV., last occurring in 1890, for which there was no previous number.

For convenience, the old style of numbering has been retained in tbis record; arranged in a different form the broods are as follows:

Riley's	brood VIII. (1889) =	Marlatt's brood	XIV.
"	no number (1890) =	" "	XV.
"	brood XII. (1894) =	" "	II.
"	" XVII. (1898) =	" "	VI.
"	" XXII. (1902) =	" "	X.

Injury Caused.

Only from Hunterdon county, the chief infested area, have I had any reports of injury caused by this insect to shade or orchard trees. It has been quite remarkable how generally fruit trees escaped, even where the insects were plentiful. In several places I saw wood-covered hillsides, where almost every deciduous tree showed broken or dying twigs; the apple trees in the orchards almost adjoining the wood showed no traces of injury. The explanation given in Mr. Pettit's record is in accordance with this observation. The insects do not voluntarily travel mnch, and do not, ordinarily, get out of the patch of woodland in which they appear. So long as they have plenty of food and plenty of room for laying eggs they do not spread. Where

woodland has been recently cut off and fruit trees have been set, injury has come because the insects came up near the trees and found them convenient for their purposes. Except in Hunterdon county, there is little such recently-cleared land in orchards in the infested area.

An interesting account of his experience was supplied by the Rev. F. J. Tomlinson, of Pittstown, under date of September 1st, 1902. He says: "They came on in veritable droves every warm night for about three weeks. I have a small orchard of about seventy-five trees. I thought to keep them off at first, so just as it was growing dark I would take a large bucket (holds about four gallons) and a stick and sweep off those that were ascending the trunks. I would get the bucket three-fourths full by the time I went over them. I did it a few nights, then gave up in despair. * * * The greatest damage for us was to a young apple orchard, two years old, in which many trees were stung so badly that I cut off the entire top. I do not know whether they are worth saving—about a hundred trees. We have also a peach orchard, two years old, which is badly stung. In some cases I have trimmed out all stung branches, and that leaves a badly-shaped tree, for they seemed determined to sting the strong main shoots. * * * Now, I will tell you something about my young chestnuts: I grafted 1,066 and have 475 growing. * * * The locusts did considerable damage to both stocks and grafts. I tried cutting out the eggs, but that so badly mutilated the stocks that it is a problem whether the remedy is not about as bad as the disease. One thing, I think, was greatly in our favor—that was the cold, wet weather that prevailed much of the time while they would have been most active. But for that, it seems to me, they

Fig. 3.
Cicada punctures showing, at *a*, how the twig breaks. After Riley.

would have made almost a clean sweep of all our young stuff. They did kill a number of young grape vines for us, and also young English walnuts. I was among my young chestnuts much of the time during the two or three hottest days, when most of the damage was done, and kept them from doing as much damage as they would. It takes them a little time to get down to business, and before much was done I would be around with my protest, which was generally a good squeeze."

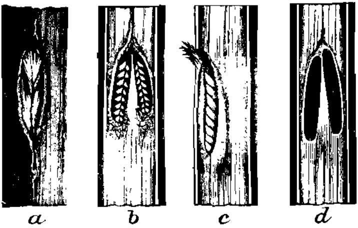


Fig. 4.

Cicada egg puncture: *a*, as it appears outwardly; *b*, cut through the face of same; *c*, cut from side, showing a single cell with eggs in place; *d*, cells emptied of eggs; somewhat enlarged. After Riley

As to the character of the injury, that is shown in Figures 2 and 3, from my Report for 1894. The females, by means of their augur-like ovipositors (Figure 5), cut slits into twigs and branches, usually toward the tip and in new growth; yet, sometimes in older wood, and even in the trunks of young trees. These slits are made to hold the eggs and they go deep into the tissue. The twig or small branch is much weakened thereby and a high wind twists or breaks it. It drops or, most usually, hangs for a time; a sure index of the recent occurrence of this species. Sometimes the nutrition of the shoot is so interfered with that, even if it does not break, the foliage dies and the mark is as conspicuous as if there had been an actual break.

The eggs laid in the slits hatch during August and the young larvæ at once drop to the ground and burrow out of sight.

That the adults do some feeding is now pretty well established, but it is so little that practically no harm is done in this way. The larvæ grow so slowly and feed so little that that does not injure the infested roots. It is only in the act of egg-laying that the female does injury to growing plants.

In the forest this is only a summer pruning and is readily outgrown. In the orchard or nursery matters are more dangerous, especially on young trees, which are sometimes crippled.

Life History.

The life history of this insect has been written in previous reports, and in that for 1894 some structural details, with the peculiar chimneys or cones, were described and figured. The egg-laying habits are discussed in a previous section. After the larvæ hatch from the eggs and drop to the ground, they make their way below the surface and attach themselves to the roots of trees and shrubs. They may go down along these roots for a considerable distance and are rarely found near the surface much before the time when they are due to appear as adults. They do no real injury in this stage, growing as slowly as they do, and feeding so little. Sixteen full years are required to bring them to the point which, on the seventeenth, they attain when adult.

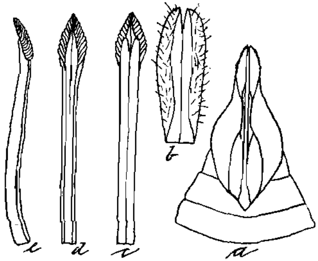


Fig. 5.
a, end of female abdomen from beneath ; *b*, sheath inclosing tip of ovipositor ; *c*, ovipositor from below ; *d*, same from above ; *e*, same from side—enlarged. Original.

The song produced by the males and the ovipositor of the females are explained in the 1894 Report. The song is really the rapid vibration of a stiff, convex membrane, the sound intensified by other thin membranes acting as sounding-boards. The females, which do not sing, have been accused of stinging, but a reference to Figure 5 will readily show that the "sting," while excellent for boring into wood, is hardly adapted for the rapid piercing of a muscle.

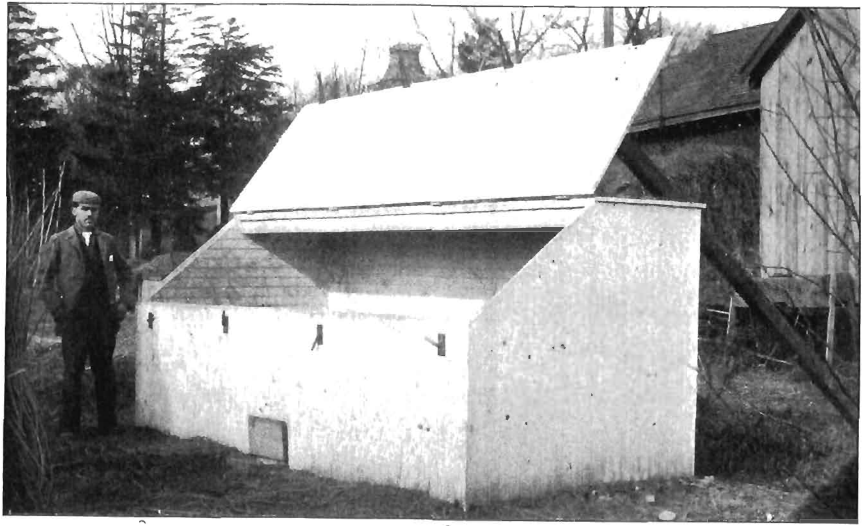


Fig. 6.
The Fumigating Box at Parry. From an original photograph.

Remedial Measures.

There are none that are reliable when these insects are abundant. Whitewash comes nearest to being a preventive, since they do not like to rest on a white surface; but even this fails when proper, uncovered twigs are lacking.

We can only, when we know that the species will occur, arrange our orchard practice so as to leave plenty of growth for them and no young trees to tempt them.

Forecast.

This brood is due to reappear in 1919, and it will at that time be much reduced in extent. Wherever it appeared near towns or villages where the sparrows are dominant, the probabilities are that it will not reappear. The southern colonies are all much smaller and less extensive than they were seventeen years ago, and it is likely that some of them will disappear altogether. The strongholds of this brood are in Hunterdon, Mercer and Somerset counties, and to these it will, very probably, be confined on its next appearance. It is very unlikely that it will be my pleasure to record this brood again.

FUMIGATION.

Fumigation, as this term is used here, is the process of submitting nursery stock to the action of hydrocyanic acid gas in an airtight box or chamber for a length of time sufficient to kill insects without causing injury to plants.

Hydrocyanic acid gas is produced by the action of dilute sulphuric acid upon fused cyanide of potassium, and the gas thus liberated is intensely poisonous to all animal life from man down. Cyanide of potassium is itself a deadly poison, and sulphuric acid is a violent corrosive; therefore, the first point in connection with this process is the absolute necessity for care in its use.

The materials themselves must be of good quality to produce the best results: much of the imperfect work done when the process was first developed being due to the impurities in the cyanide, the acid or in both.

The cyanide of potassium must be 98 per cent. pure and the sulphuric acid should have a specific gravity of 1.83 or be of the best

commercial grade. Chamber acid will not do. Any reliable firm of dealers in chemicals can supply both of these materials. The Roessler & Hasslacher Chemical Co., 100 William street, New York City, has made rather a specialty of supplying the proper grade of cyanide at the lowest prices, ranging from thirty-two to thirty-five cents per pound, according to quantity. Sulphuric acid is so generally used in the arts that the proper grade may be easily obtained from any drug or chemical company.

To produce the gas there should be one part by weight of the cyanide, one and one-half parts, by measure, of the acid, and three parts, by measure, of water. This would be expressed in the following formula:

Cyanide of Potassium, 98 per cent. pure	1 oz.
Sulphuric Acid, Commercial (sp. gr. 1.83)	1½ oz.
Water	3 oz.

This formula will be considered standard for the purposes of this paper, and hereafter only the amount of cyanide will be given, leaving the amount of acid and water to be figured out on the basis above given. Any glazed earthenware vessel may be used as a generator. Metal receptacles of any kind corrode rapidly and wooden vessels char. Glass will answer as well as earthenware, but is apt to be more expensive and is more liable to break.

In preparing to fumigate, always weigh out the cyanide first and place it in small lumps in a thin paper bag. Where the fumigating charge is always the same, it is well to weigh out the cyanide into bags at the beginning of the season, as this will make it easy to pick up a bag whenever needed without the delay of weighing out. Keep the bags in closed boxes or jars, as the action of the air deteriorates it. Put the proper amount of water into the generator first. Then add the acid slowly and, when the two have united, drop in the bag of cyanide and close the box, chamber or house. The order given is important and should be closely followed. The combination of sulphuric acid and water produces heat, and the mixture, when complete, will be hot or warm, according to the rapidity with which the acid was poured in. Pouring the acid into a larger body of water warms this up gradually and only a little steaming or boiling appears. Should water be poured into the acid, so violent a boiling would take place when the first few drops of water combined with it that there would be a serious splashing that might cause breakage of the jar or a scat-

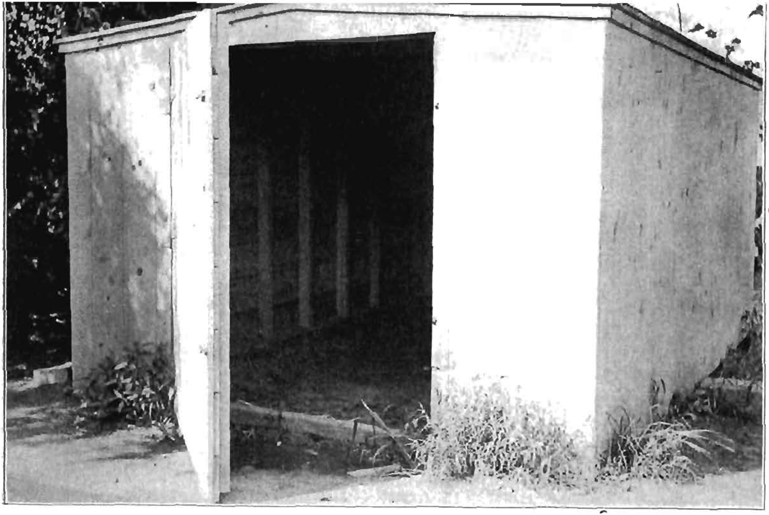


Fig. 7.

The Lovett Fumigating House. From an original photograph.

tering of the material. Therefore, always measure out the water first *and then pour the acid slowly into the water*. By dropping the cyanide yet inclosed in the paper bag, the formation of the gas is retarded until the liquid penetrates the paper; a few moments only, but long enough to make it possible to close the box or room and thus prevent loss of gas.

Orchard fumigation is not deemed feasible at present for New Jersey conditions, and no detailed directions for such work will be given here, but some general suggestions may be useful and will be given later in this paper. For the first, nursery conditions only will be considered, and the day is not far distant when fumigation of stock will be a matter of routine on every well-conducted establishment. In New York and some other States, fumigation is absolutely required at all nurseries, and there is no doubt that this forms an element of protection to the purchaser that is of the highest value.

In New Jersey fumigation is not required by law, but as stock must be fumigated to admit it into some foreign States, most of those doing other than a local trade have built more or less suitable boxes or houses. The first box built in this State was at Parry, and a picture of this is given herewith, reproduced from my Report for 1897. The box was well built, entirely suited to its purpose and was a model for a number of others used on small nurseries. The stock was here piled into the box on a slat floor, keeping it well above the ground, the cover was firmly fastened down and the chemicals were placed in a small drawer, which opened out at the middle of the front. When the jar was properly charged the drawer was shoved to the middle of the box, the lid to the outside was dropped into place, covered with heavy blanketing and weighted to make a tight joint.

The only objection to this box was its small size and the relatively great cost in time and labor of treating the stock of a large nursery.

Experiments with the gas were now in progress in several States, and no one did more to develop the practical usefulness of the process than Professor W. G. Johnson, at that time in Maryland, and now on the staff of the *American Agriculturist*. His book on the subject is a standard and necessary to all who would understand the application of the method to all sorts of plants under all sorts of conditions. I have drawn upon this book for such of the information here given as is not within my own experience.

The first house of any size was built on the Lovett Nurseries, at Little Silver, and there is not a better-built house for the purpose

anywhere in the country. It is as nearly air-tight as such a house can be built, and the door, closing like a refrigerator door, against a felt seat, and held in places by cleats that tighten like a wedge, makes it a perfect "fumigatorium."

The largest house at present in the State is on the Village Nurseries, at Hightstown, and this was built to accommodate the needs of a very large establishment. An entire wagon load of trees is here fumigated at one time, the gas being generated on the floor and getting an excellent chance to diffuse throughout the mass. The effectiveness of this house was tested by placing some very scaly trees *in the midst of a load and then setting them out in a remote corner* of the farm. They all grew and not a scale developed on any of them at any time during the season following.

There is no need to show in detail other houses, since, in their essentials, they are alike; but it will be interesting to show for comparison a picture of a fumigating-house in Georgia, which I owe to the courtesy of Mr. W. M. Scott, the State Entomologist and chief inspecting officer of that State. No house in New Jersey, so far as I know them, has more than one room. The one shown here has three, differing somewhat in size, and the house can be kept constantly going during the shipping season, while, if only a small lot of stock needs treatment, the smallest room can be used. During the season when no fumigating is done, the building is very useful for a variety of purposes.

Enough has been said and shown to indicate that no one type of house is essential; but every house, to be satisfactory, should have the following points:

First. It should be as nearly air-tight as possible; any building through which daylight is visible when the doors are closed is a mere evasion and make-believe, from which satisfactory work cannot be expected. To be really safe the house should have double sides, with building-paper between, and a match-board ceiling. The sills should be imbedded in the soil and the outside sheathing should be closely joined, to cover them to the surface. The roof may have any pitch, but it will be better to have a flat ceiling to the room, as it will require less material to fumigate.

Second. The doors should close over a broad ledge, guarded by felt, against which they can be tightly pressed by any suitable contrivance. So, there should be some provision to make a tight joint at bottom.

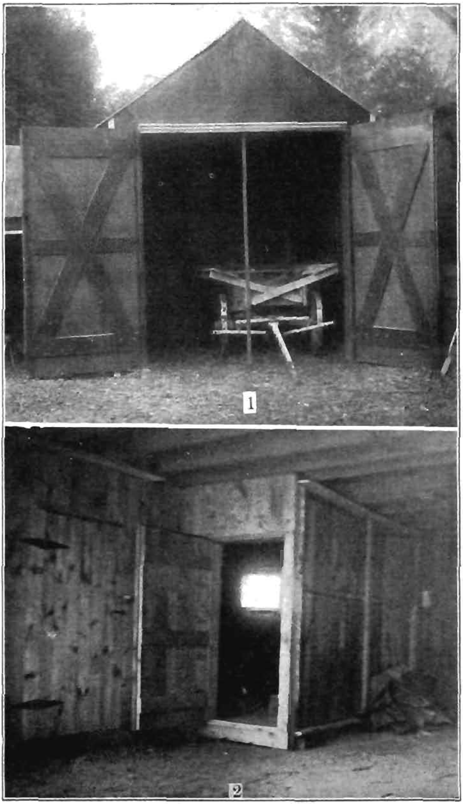


Fig. 8.

1, The Fumigating House at the Village Nurseries; 2, Fumigating Room at the Pleasant Valley Nurseries. From original photographs.

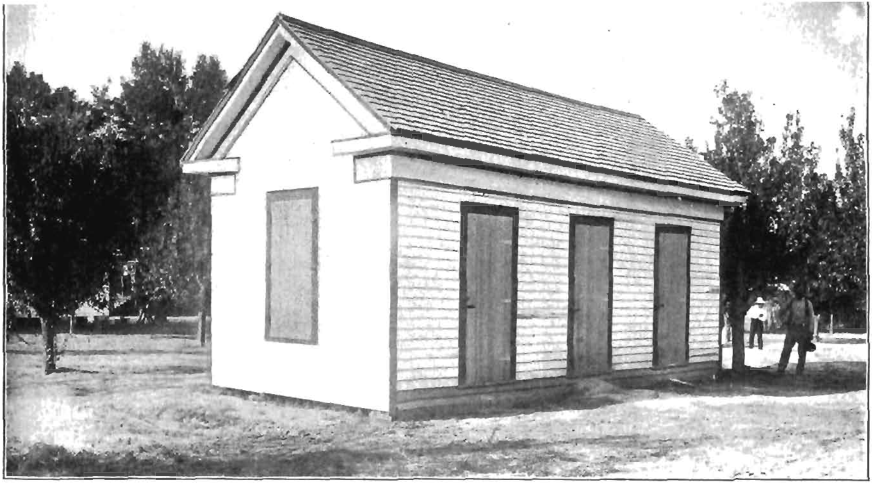


Fig. 9.

A Georgia Fumigating House. From a photograph supplied by W. M. Scott, State Entomologist of Georgia.

In a house like that on the Village Nurseries this is obtained by shoveling sand to cover the joint when the door is closed.

Third. There should be a slatted floor, raised from six to twelve inches above the ground level, so as to allow a free circulation of gas below the mass of stock piled above, and the jar containing the cyanide, etc., should be on a level below that of the slat floor. *If the stock is on a wagon, the floor of the wagon body should not be* too solid, but in that case no slatted floor is needed.

These may be considered the essentials of a really satisfactory house. A very desirable addition is a method of allowing the gas to escape rapidly, after the stock has been exposed to it for a sufficient length of time. This is usually accomplished by means of a window opposite the door, that may be opened from the outside. It should close as tightly as the door, with a solid shutter. Experience has shown that if light be excluded the gas is more fatal to insects and less dangerous to plants. Therefore, though a glass sash may be inside, there should be a solid shutter outside of it. An even more effective ventilation is a heavy door in the roof, that may be lifted by means of a pulley from the ground before the doors are opened. In opening the doors care should be taken not to get the first rush of gas from the house. Headache and vertigo have followed carelessness on this point and worse results are not excluded.

The place for the jar with the fumigating material is in the centre of the house, unless it is so long that two jars are desirable. A house over fifteen feet long should have two jars in the mid-width, but at one-third from the back and front. It will be easy to rig up some sort of contrivance to suspend the cyanide bags over the jars until the door is ready to be closed, or they may be balanced on a narrow strip, so as to be readily shoved into the jar by means of a long rod. Where only a single charge is needed, a passageway may be left from jar to door, and, after dropping the bag into it, a rapid retreat to the door may be accomplished before gas is generated.

Given a proper construction and the necessary arrangement for generating the gas, the house may be completely filled with stock from slat floor to roof. It should not be tied in tight bundles, but need not be too loosely placed. Give the gas a chance to circulate and allow nothing on the plants that might shelter or cover the insects.

Time and Quantity.

Only dormant stock should be fumigated, and evergreens (conifers) should never be exposed to the gas. Practice has shown that, except for peach and plum, one ounce of cyanide for every 100 cubic feet of space is a safe mixture, and that the trees may safely remain exposed in the house during the night. Good peach and plum stock will stand the same charge for an hour with safety, but may suffer if allowed to remain over night. Three-fourths of an ounce has proved safe for an all-night exposure. It seems to be the conclusion of those who have studied this point most carefully that a large volume of gas for a short time is more effective against insects and safer on trees; hence, one ounce of cyanide on peach, exposed not over an hour, is better than three-fourths of an ounce exposed all night. It has also been proved that the pernicious scale succumbs to the gas, if perfectly diffused in sufficient quantity, in half an hour and at a minimum of three-fourths of an ounce to 100 cubic feet of space. This latter charge—three-fourths of an ounce of cyanide to 100 cubic feet of space—with an exposure lasting forty minutes, should be used for June-budded peach, for weak, imperfectly dormant stock and for buds, grafts and scions. These should be loosely piled, to allow the rapid diffusion of the gas.

Perhaps this is a good place to say that no tree known to be scaly should ever go into the fumigating house with the idea of sending it to a customer who expects to get clean trees. Fumigation is a process that is meant to supplement inspection and not to replace it. It is as near perfection as we may hope to get, but is no more infallible, even when done with the utmost care, than any other process known to us for any purpose.

It is sometimes supposed that if one treatment is good, two of the same kind ought to be better, but this does not apply to fumigation, and trees known to have been once treated should not be submitted to a second application; and especially is this true of peach. Nor should trees be treated when they are wet. The gas seems much more injurious to them in that condition and I have seen apple and pear come out of the house and grow lifeless and soggy almost at once. Moisture is not needed to assist the action of the gas, but a little dampness is not necessarily harmful. Never should the trees be laid directly on a damp, earthen floor. The gas could not get at the surfaces in direct contact with the soil.

After fumigation there will remain in the jar a liquid or pasty mass which crystalizes if left for some time. This residue should be buried or disposed of in such a way as not to get into the way of animals. It may be placed in the manure pit, adding as it does a little potash and sulphuric acid.

Range of Effectiveness.

Fumigation as at present practiced is primarily directed against the pernicious scale; but it is powerfully effective, also, against many other insects not in the egg stage. It will not rid nursery stock of either oyster-shell or scurfy scale because these winter as eggs under the scale covering. It will not kill eggs of the apple plant lice at ordinary exposures, nor any other egg masses that may be on the stock. It will kill peach root lice, woolly lice on apple and other stock, blister mites on pear, pear psylla and any insects in the larval, pupal or adult stage that may be wintering on the stock.

It is by no means a cure-all, but it does reach more species than any one other process that is known to us, and the nurseryman that sends out a fumigated tree does better for his customer than one who does not, even though the latter had no trace of "scale" in his nursery.

Other Fumigating Devices.

It sometimes happens that a nurseryman has only a carload or two of trees and does not wish to build a fumigating house or box, and from such I have met the question again and again whether the stock could not be fumigated in the car. It can be done if the car is used as a house would be and is cleared of the gas before the trees are finally packed. But if the car is loaded with stock bundled in the usual manner—roots protected by wet moss, etc., and the fumigation is done just before sending off—the chances are that material injury to the stock will be caused. A box freight car does not ventilate easily, and the gas may remain banked at the ends for some time, causing injury. The wet roots will tend to absorb the gas and injury is here likely, while, finally, the chances for the scale insects to escape the action of the gas are very much increased.

The simplest way to fumigate stock is to pile it on a rack, cover with oiled canvas, bank up with soil over the canvas at bottom and then place the charge beneath it. This was the Californian method

some years ago and yielded very good results; but it is uncertain in its effects upon both plants and insects and is not to be encouraged. Accurate determination of the amount of cyanide necessary is difficult, while material error one way or the other may mean death to the plants or life to the insects. In order to make the process at all allowable, the canvas cover must be gas-tight.

Orchard Fumigation.

This point has been touched upon. For small trees in a young orchard or for dwarf trees, fumigation is entirely practical and effective. I am quite aware that very large trees are fumigated in California, but there individual holdings in orchard far exceed anything that we have in New Jersey, and expensive outfits are good investments. Furthermore, California is so much a horticultural State that county or other local authorities own outfits for the benefit of their constituents, while the amount of work to be done is sufficient to make it also worth while for private enterprise to invest the necessary capital for the outfit that enables them to contract to do it.

Orchard fumigation in New Jersey is best done in fall, when the foliage has served its purpose and while the scales are not yet tending to become dormant. The essential for successful practice is a gas-tight cover of some sort that will serve to enclose the tree while it is subjected to the gas. All sorts of boxes and tents, portable, adjustable, fixed and knock-downs, with all sorts of contrivances for placing and removing them have been invented, tried, improved and perfected. An excellent account of the different forms of tree covers is given by Professor Johnson in his book on fumigation, but it means in effect that there should be a cover of eight-ounce oiled duck or a box of thick building-paper, so put together as to be gas-tight when placed over the tree. The charge for such fumigation is four-fifths of an ounce of cyanide per 100 cubic feet of space, or in that proportion, and the time of exposure is from thirty to forty-five minutes.

Greenhouse Fumigation.

On this point I have no personal experience whatever and base the suggestions made here upon either results obtained by Dr. A. F. Woods, of the Division of Vegetable Physiology and Pathology in

the United States Department of Agriculture, or upon the records contained in Professor Johnson's book, already cited.

First of all, it will be necessary to determine very accurately the cubic contents of the house; next, it will be necessary to make it gas-tight, while also providing that some ventilators may be opened from the outside, to permit the escape of the gas. The plants must not be wet, nor must the floor of the house be wet, but it may be damp. Moisture intensifies the action of the gas on the plants and so does light; therefore, greenhouse fumigation should be done only at night.

Under these conditions one ounce of cyanide to 300 cubic feet of space is safe on ferns, while killing the scales which infested them in twenty minutes. Coleus infested with mealy bugs were cleared in the same time, using one ounce to 250 feet, while double English violets were cleared of all save red spider by increasing this dose to one ounce in 175 cubic feet. Single violets are more susceptible, and will not stand more than one ounce to 250 feet. Tomatoes were cleared of white fly by using one ounce to 1,000 cubic feet and retaining the fumes all night. Lice were cleared from melons by fumigating all night with one ounce of cyanide to 175 cubic feet. Roses, *carnations and chrysanthemums have not been safely treated.*

Enough has been said here to put the owner of a greenhouse upon inquiry. The subject is yet in its infancy and will repay experimentation. Professor Johnson's book should be carefully studied and the strong point mastered, that when the grower has once fully determined what his plants will stand safely, he has the insect enemies of these plants entirely at his mercy.

Small Fruit Fumigation.

In the discussion of methods of fumigating "nursery stock," that term has been used as applying only to tree stock. As a matter of fact, all the usual hardy, shrubby plants and small fruits, such as currant and gooseberry, may be treated on the same basis as peach. But plants like strawberry stand on a somewhat different footing. Strawberries are not subject to San Jose scale attack, but they are subject to infestation by a root-louse, that sometimes causes serious injury; hence, some States demand that strawberry plants shipped within their borders should be fumigated.

In Bulletin No. 149 a box for fumigation of this character is figured and described. The figure is reproduced here as Figure 10, and the description of the box and how it is to be used is as follows: "This box is 2 x 2 x 2½ feet, without a bottom, made of two thicknesses of matched wainscoting, with building-paper between; the cover closes upon a rabbet the depth of the thickness of the material and lined with felt; a small door, about 6 x 6 inches, is placed at the lower corner and similarly fitted so as to close on the felt; four or five frames, covered with wire netting, rest upon cleats, the lower one being about three or four inches above the ground and extending to the small door, and the rest of the trays extending clear across the box, being about five inches apart. Such a box will hold from 1,500 to 2,000 loose plants, placing only one layer on a frame, which permits a quick and thorough diffusion of the gas. The only apparatus necessary is a cup or tumbler in which to generate the gas."

This box contains *ten cubic feet*, and requires *forty-five grains* of cyanide for a ten-minute fumigation. For such small quantities, the cyanide, which must be 98 per cent. pure, is best dissolved in two drachms of water, and this had better be done by a druggist, who can make up, in separate vials, as many doses as may be needed. There should be an equal number of vials of the best-grade commercial sulphuric acid, each containing one and one-half drachms of the acid.

When ready for work, place the box on a level spot so it rests solidly all around, bank up on all sides to six inches or more and pack firmly. Place the plants upon the trays in single layers, close and fasten the top, uncork the vial with the cyanide solution and put it mouth downward into the cup; immediately thereafter drop in the acid in the same way, shove the cup into the box through the lower opening, close the door tightly and keep closed for full ten minutes. Then lift the top and allow the fumes to escape before taking out the plants.

A box of this kind will answer excellently well to fumigate buds, grafts or scions, but the time must be increased to half an hour in such cases. It goes without saying that this kind of box may be increased in size to any desired point, as circumstances may demand. What is given here is the principle to be kept in mind and a basis upon which practice may be founded.

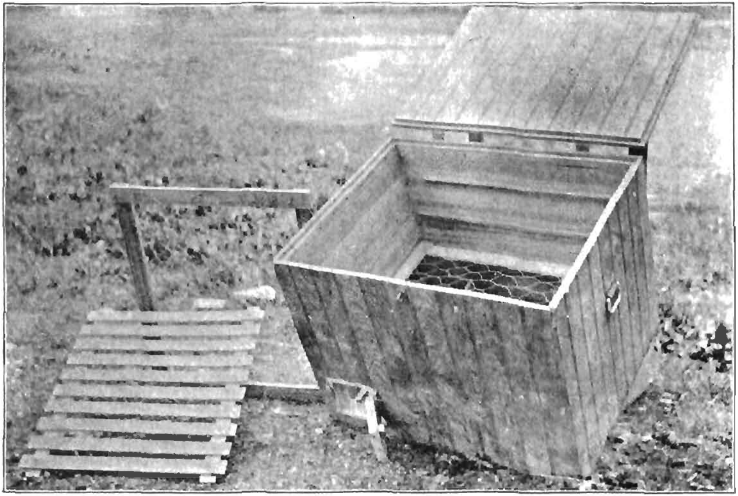


Fig. 10.

Fumigating Box for strawberry plants, buds, grafts, etc. From Sanderson in Delaware Experiment Station.

Other Objects for Fumigation.

It sometimes happens that dwellings become infested with household pests unpleasant in character, and the question of how to deal with them becomes a matter of real importance. On this point the experience of the South African Cape Town railroad, as recorded by the official Entomologist, may be of interest. The habits of some of the patrons of the road were such that the passenger cars became infested with bed-bugs to an intolerable degree, and the Entomologist was appealed to for help. He suggested the construction of a room large enough to contain a car and tight enough to hold gas. His suggestion was followed and the results were perfect. Car after car was cleaned at very little cost in money or trouble, and the bug problem is solved for that company.

It happens, sometimes, that an old house becomes so infested by vermin that ordinary means fail of their usual effect. Heroic measures must be resorted to, and the best of these is hydro-cyanic acid gas. Any room can be completely cleaned of all undesirable guests by fumigating with this gas at the rate of one ounce to 100 cubic feet of space. Of course, the room must be unoccupied, and there should not be any unnecessary hangings, curtains or draperies of any kind. All closets, doors and all drawers must be open, all furniture moved away from the walls, and the windows made as nearly tight as possible with cotton or other stuffing. Nor will one application be sufficient. It has been stated that the gas does not kill insect eggs, and, as eggs of the household pests may be present, a second fumigation, a week or ten days after the first, is necessary to make certain of complete results. The gas should be allowed to act for full twelve hours, if possible; and it will, in that time, reach all roaches, as well as mice and other vermin that may be in its way. Room after room may be so treated and the entire house cleaned out.

Other cases where this gas will prove useful may occur, and what has been already said will be found applicable to these as they arise. It should always be kept in mind, however—*first,* that this gas is a deadly poison for animals of all kinds, promptly; and for vegetation, in a litle longer time; *second,* that to exercise its effect it needs a confined space.

CRUDE PETROLEUM.

This has been, on the whole, the main reliance for keeping in check the San Jose or pernicious scale during the period that has elapsed since the last report. I have made no new experiments and have nothing to add from personal experience; but I have seen many sprayed orchards, have had written reports from many others and have had verbal reports from growers all over the State. The value of an insecticide as such may be determined by laboratory tests and by applications under careful supervision and control; but its practical usefulness is determined by its effect in the hands of the man who applies it in a commercial orchard under ordinary farm conditions.

For my own use, undiluted crude petroleum of the proper character (43° or higher) is preferable to any other material. In the hands of many of our orchardists it has approved itself excellently; but there is an element of danger that increases as the necessity for entrusting its application to ordinary farm help arises, and this cannot be ignored. It has proved, too, that the liability of a plant to injury depends somewhat upon obscure conditions within itself, or upon climatic conditions which we have not appreciated as yet. Hence, the tendency has been to abandon the undiluted applications in favor of emulsions or mechanical mixtures containing 20 to 25 per cent. only of the oil.

These mixtures have been very largely used in some of the Southern States and form their main reliance at present. In Georgia, the emulsion is given first place over the mechanical mixture because of the possibility of more even applications.

It seems remarkable that even pumps made under modern mechanical conditions should have an individuality, but so it is, and while some emulsion pumps work evenly and well, others are absolutely not to be depended on. This is not a difference in makes of pump, but between pumps of the same make, and a cranky pump is almost as unreliable in the hands of a good mechanic as of an ordinary colored farm help.

The question of cost is always an important matter, hence the following report will be of interest:

"My Dear Sir—I took the advice contained in your letter of January 7th and purchased a Gould's Kerowater spray pump. Owing to the first machine being lost *en route,* I did not receive the second

until near the middle of March. Began spraying 25 per cent. mixture March 14th, and worked steadily, on favorable days, until March 31st. Some of the oil was marked insecticide oil and other barrels crude oil.

"Used six barrels oil on seventeen acres—about one barrel to three acres on about 1,900 trees, or about one and one-third pints per tree. Trees mostly peach, five and six years old. Some peach sixteen years, others one year, and a few apple trees. The pump worked very nicely, and after organizing the spraying party I had no further trouble. Of course, the cost of pump, oil and time was considerable.

Cost of spraying outfit	$22 50
Six bbls. oil, net	26 25
Labor	27 00
Incidentals	1 00
Total	76 75

Cost per acre, $4.50; cost per tree, four cents. Deducting two-thirds of cost of machine, the cost per acre would be about $3.50. The cost per tree would be three and one-quarter cents. We sprayed with the wind, using Vermorel nozzle, doing the other side on change of wind.

"The outfit in the field was as follows: Two-horse team and farm wagon, containing two men, one to drive and pump, one to spray; *spraying barrel, one oil barrel, tapped, and one water barrel; starting* from place in morning and at noon, with machine filled; carried through one-half day. Strained all the oil and all water used from brook or spring.

"If the 25 per cent. mixture proves to be effective, it would be a considerable saving. I could not have gotten along with less than twenty barrels of undiluted oil, as the trees are large.

"Owing to delay in receiving my pump, I had to spray in windy weather, and did not do a perfect job. The latter part of February this year was altogether unfit to spray, owing to snow, ice and fallen limbs and branches. The first part of March was the best time, just before my pump came. The latter part was windy. Seasons vary greatly. I think December would average a good spraying month.

"P. S.—The labor charge above noted is the minimum. Allowed only $1 per day per man and fifty cents per day per horse. As I sprayed in the busy pruning and trimming season, I should have increased labor 25 per cent. at least. If the work was done in favorable midwinter weather, the cost would not be any more than I stated,

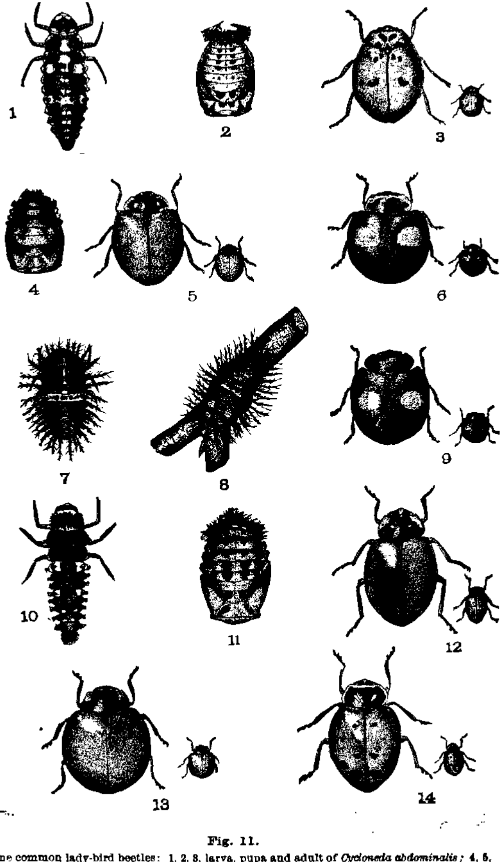


Fig. 11.

Some common lady-bird beetles: 1, 2, 3, larva, pupa and adult of *Cycloneda abdominalis*; 4, 5, pupa and adult of *C. sanguinea*; 6, adult *C. oculata*; 7, 8, 9, larva, pupa and adult of *Chilocorus cacti*, which resembles both *C. bivulnerus* and *C. similis* in all stages; 10, 11, 12, larva, pupa and adult of *Hippodamia ambigua*; 13, *Coccinella californica*; 14, *Coccinella convergens*; small beetle figures indicate natural size. From the Div. Ent., U. S. Dept. Agl.

THE CHINESE LADY-BIRD,

Chilocorus similis.

The Coleopterous insects belonging to the family Coccinellidæ, or, to put it otherwise, the beetles commonly known as "lady-birds" or "lady-bugs" are generally recognized as beneficial to the farmer, because of their habit of feeding on plant lice and scale insects. This predatory habit is not without exception, because we have in New Jersey one species that feeds, in both the larval and adult stages, upon the foliage of cucurbit vines. Other species occasionally feed on pollen, and not a few tend to vary their diet by lapping up sweet excretions from plant surfaces. Most of the species are rather small in size and some of them are very minute, not exceeding in diameter the head of an ordinary pin. On page Figure 11 is given a series of illustrations showing some of the more common types.

Two rather easily known series occur; species which are of some shade of red or yellow and are spotted with black, and species which are black, with yellow or red spots or without any markings at all. In a general way the beetles belonging to the first series are the larger, are more oval in outline and feed upon plant lice. The insects belonging to the second series are smaller, rounder in outline, almost hemispherical in some cases, and, generally, they prefer scale insects as food. To this latter series belong the species of *Rhizobius,* which were introduced from Australia into California to check or destroy the black scale. In New Jersey, though we have a number of species of scale feeders, there are only two that are at all numerous—the species known as the "twice-stabbed" lady-bird (*Chilocorus bivulnerus*) and the very small Pentila, which is hardly larger than the pernicious scale itself.

The "twice-stabbed" lady-bird is shining black, almost hemispherical, about three-sixteenths of an inch long and with a blood-red spot on each wing cover. Figures 7, 8 and 9, on plate Figure 11, represent this species in all its stages well enough to enable it to be recognized, since we have nothing else that is similar to it in the State. With us this insect has two broods, never becomes very plentiful and lives through the winter in the adult stage.

When, in 1896, I traveled through the scale-infested regions of California, I found in the southern section that this very species, the "twice-stabbed" lady-bird, was the most important agent in keeping

the pernicious scale in check. It occurred everywhere in swarms, and larvæ as well as adults were active in feeding on the dormant scales. I found, also, that instead of two broods, as in New Jersey, the insect had at least five or six, and instead of lying dormant for six months or more, *it was almost continuously active throughout the year.* The difference in climatic conditions, therefore, enabled the insect to do in California what it could not do in New Jersey, and this point I endeavored to bring out in my Report for 1896.

As Japan was at that time supposed to be the home of the pernicious scale, I made an effort to obtain scale-feeding lady-birds from that country, but did not succeed until the spring of 1898 in securing live specimens. On pages 446 and 447 of my Report for that year some details are given of this importation, but it is enough to say here that nineteen living examples of *Chilocorus similis* were liberated on scale-infested trees in a Riverton orchard, May 24th, 1898. Nothing was seen of these insects later and it may be assumed that they perished.

During the season of 1901, Mr. C. L. Marlatt, first assistant in the Division of Entomology of the United States Department of Agriculture, traveled rather extensively in China and Japan, carrying on the while his studies on scale insects and their habits. Among others he found the pernicious or San Jose scale in both China and Japan. From evidence satisfactory to him he determined that Japan was not the native home of the insect, but that it had been introduced into that country from the United States. He also determined that Northern China was the real home of the pernicious scale and that its natural check was this very *Chilocorus similis.*

Specimens were collected and sent to Washington, where they were looked after, and some safely carried through the winter. Mr. Marlatt's account of this species and of his experiments has not yet been published, but he was good enough to inform me that up to the middle of July, 1902, there had been three generations. "One cage in which two individuals were placed early in May, supposedly a male and a female, as they were in coitu, is now thickly stocked with them, often seven pupæ clustered under a single pear leaf, and no exaggeration to describe the cage as having hundreds of specimens."

At the Pittsburg meeting of the Association of Economic Entomologists, in late June, Mr. Marlatt was good enough to promise to send me some specimens, and this promise he repeated under date of July

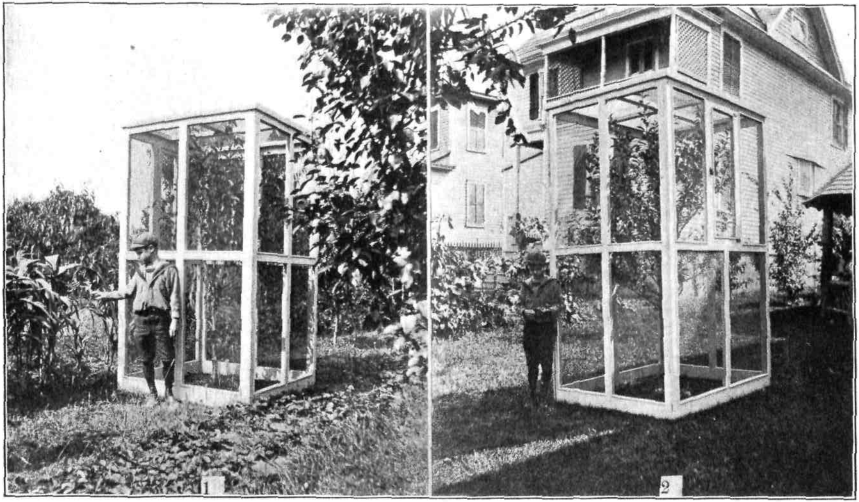


Fig. 12.

1, Cage covering tree No. 32 in the experiment orchard; 2, Cage covering tree No. 36, same place. From original photographs.

8th, sending me at the same time a photograph of the cage used by him.

An inspection of the Experiment Orchard showed that trees 32 and 36 were the smallest badly-infested trees, and these were selected for covering. No. 32 is a Lawrence pear, and it was found very full of scale, ranging from crawling larvæ to breeding females. All parts of the tree were infested and even the leaves were beginning to be covered. Tree 36 is an apple of unknown variety, and it also was then swarming with larvæ of the second brood. The cages were received July 21st and were set in place on the 22d. That covering tree No. 32 is 4 x 4 x 7 feet, and is shown at Figure 12, 1. That covering tree No. 36 is 4 x 5 x 8 feet, and is shown at Figure 12, 2. The beetles, twenty in number, were received on the morning of the 23d and were at once placed on the covered trees. They were active and were equally divided between the two cages. No attempt could be made to determine the sex of the individuals.

The trees were kept under continual observation, and some of the beetles could be readily seen at any time, usually on the trunk or larger branches. Numerous white points where scales had been torn off could be also seen, but always there were also plenty of young out toward the tips of the shoots.

Up to August 12th no traces of larvæ were seen, but it was, of course, possible to overlook them among the foliage or on the badly-infested inner branches. Mr. Marlatt says the eggs of this beetle are laid singly, beneath the scales, hence they could not be seen on such examinations as I could make. Becoming uneasy lest all the specimens should be of one sex, I wrote again, asking for larvæ rather than beetles, and on August 23d I received from Mr. F. H. Chittenden, acting for Mr. Marlatt, twenty-four larvæ, varying in size, all of which were placed on tree 36 as the larger and more scaly individual.

It has not been said that this Chinese lady-bird is so much like our own twice-stabbed species that it is not possible to tell the difference between the two on a casual examination. After some account of this species had been published in the agricultural papers, I received several letters from growers, claiming that specimens fully answering the descriptions had already appeared on their trees. The actual differences between the adults are apparent, to even the Entomologist, only after close examination, but the differences in the early stages are quite apparent. While the larva of the native form is

blackish, with a rather obvious whitish band before the middle, the Chinese larva is flesh colored. And while, as already stated, the Chinese beetle lays its eggs under a scale, the native species lays its ova openly, on the bark or leaves. Thus we have two different, if closely allied, species.

September 9th saw several pupæ and one adult just out of the pupal skin on tree No. 32, and as no larvæ had been placed on this tree, it follows that there must have been some breeding. But it was very slight indeed, and on October 22d, when I examined the tree carefully, found only a few beetles.

On tree 36 I found, September 9th, several pupæ and full-grown larvæ, but these might easily have been, and probably were, from the Washington sending.

October 2d made another careful inspection and found the beetles quite obvious. There were also a large number of pupæ, a few larvæ and some recently-developed imagoes. There had been some breeding, no doubt. October 22d noted a number of the beetles and a number of pupæ, but no larvæ.

It is obvious that on both trees the insects have bred to some small extent. The trees are yet sufficiently scaly to feed all the beetles that are on them, and, under the circumstances, it is deemed wise to allow the covers to remain and to keep the beetles confined through the winter under ordinary outdoor conditions.

a

b

Fig. 13.

a, A Steam Boiling Plant for the lime salt and sulphur wash, in Canada; *b*, a Sprayed Canadian Orchard. From photographs made by Mr. Geo. E. Fisher.

REPORT ON THE MOSQUITO INVESTIGATIONS.

(509)

REPORT ON THE MOSQUITO INVESTIGATIONS.

JOHN B. SMITH, SC.D.

By an act of the Legislature of New Jersey, passed at its session during the early months of 1902, and duly approved by the Governor, the Agricultural Experiment Station was "empowered and directed to investigate and report upon the mosquitoes occurring within the State; their habits, life history, breeding places, relation to malarial and other diseases, the injury caused by them to the agricultural, sanitary and other interests of the State, their natural enemies, and the best methods of lessening, controlling or otherwise diminishing the numbers, injury or detrimental effect upon the agricultural, sanitary and other interests of the State."

The law was not passed until late in the session, and no money was provided to carry it into effect. It was due entirely to the appreciation by Governor Murphy of the importance of the investigation that any work at all was possible, and he promptly placed at the disposal of the Station the sum of $1,000 from an emergency fund within his control.

The writer of this report was appointed to make such studies as were possible under the circumstances, and work was begun late in May, after the mosquito season was already well started. Fortunately, the work done by me during 1900, which was detailed in the Report of the Agricultural College Experiment Station, served as an introduction to this investigation, and enabled me to secure results that would have been otherwise impossible.

It will be realized that a problem so extensive in scope as is outlined in the act above referred to cannot be solved in any one year, with so limited an amount of money at hand. All that could be done was to start the work and to ascertain as fully as possible the direction in which future investigations would be likely to be most fruitful.

This, then, must be considered as a report of progress merely and as a narrative of what investigations were started.

It was realized that when the exact role of certain species of mosquitoes, in carrying or transmitting the disease organisms causing malarial fevers, was once thoroughly understood, the matter of dealing with such mosquitoes would be merely an extension of the sanitary work already in charge of boards of health, local and general; hence, I secured the services of Dr. Herbert P. Johnson, who had paid much attention to these studies, had served as an assistant in the Harvard Medical School and had also worked with Dr. Theobald Smith in the laboratory of the Massachusetts State Board of Health. A conference was had with Dr. Smith early in June, and Dr. Johnson began his work in New Jersey soon after July 1st, in quarters placed at his disposal by the Harrison Board of Health. Grateful acknowledgment is due to this board and to its members and their inspector for this and other courtesies extended.

Dr. Johnson continued his work until September 20th, and his account of what was accomplished forms a supplement to this report. It should be added that Dr. Johnson turned over to me on September 19th a very lively lot of hungry *Anopheles* mosquitoes, and that on the 24th of that month they were treated to a meal of blood from a patient suffering from malaria. The specimens were later examined by Dr. W. N. Berkeley, of New York City, but no definite results were obtained. We have no positive evidence to prove that our most common species of *Anopheles punctipennis* can act as an intermediate host for the malarial disease parasite; but against the other, *A. maculipennis,* the case is definitely proven. On this point and on the breeding habits of *Anopheles,* Dr. Johnson's report should be consulted.

The subject of the natural enemies of mosquitoes is of much greater importance than is generally realized. They need water in which to pass their early stages, and almost any kind will answer for some species. That large bodies of water do not necessarily mean large numbers of mosquitoes is a matter of common experience, and the natural question is, why is that the case? To answer this it becomes necessary to study the fauna of those places where the insects breed and larvæ are found, in comparison with those places in which they do not breed and where no larvæ are found. It is desirable to know, also, whether any of the smaller birds make use of the adults as food to any considerable extent.

This branch of the work was placed in general charge of Mr. William P. Seal, of Delair, N. J., formerly in the service of the United States Fish Commission and thoroughly acquainted with the fresh-water fauna in this section of our State. His observations are reserved for the present and will be used in the final report, to indicate the lines upon which such work must be conducted. It was hoped that it might be possible to secure the co-operation of the Fish and Game Commission of the State in the study of some of the other vertebrate enemies of the mosquito, but up to this time the effort has not been successful.

A simple observation made during midsummer will illustrate the importance of the subject. Two water barrels, close to a farm-house, became very full of wrigglers. The boy of the house, who had been somewhat interested in the subject, caught a small roach in a pond nearby and placed it in one of the barrels. In a remarkably short time, not a wriggler was left, and when the fish was transferred to the other barrel that also was cleared. Cisterns, therefore, or water barrels need only a few examples of these little fish, that occur all over our State, to make them perfectly safe. As there would be no natural nemies, even a single little fish would last out an entire season.

Another practical illustration comes in a nursery where water plants are raised in large numbers in ponds, tubs, basins and receptacles of all kinds, indoors and out. Conditions for mosquitoes would seem to be ideal; but in every tub, every pond and every pool little fish have been placed, and in the course of a somewhat hasty inspection I found no trace of larvæ. I was assured that there were none, and learned immediately thereafter that the tank connected with the copying press, in the office, having been neglected for a week, had been found swarming with them.

Mr. Seal, besides carrying on the line of work already referred to, collected carefully, from all sorts of places, mosquito larvæ, which were sent me alive, and thus I obtained several forms of great interest; one of them never before bred.

Mr. J. Turner Brakeley, of Lahaway, was a voluntary assistant, to whom I owe a full line of specimens from the pines, accompanied by full records of careful observations. Some of these observations have been already used, some are referred to in the body of this report and some will form part of the life history of the species that I hope to present in a final report. Two species never before bred by any one

were obtained at Mr. Brakeley's place in the pines, and other species not before bred by me were also received. Altogether, Mr. Brakeley's contributions toward a knowledge of the life history and habits of the New Jersey mosquitoes are of the highest value.

Mr. E. L. Dickerson, of Newark, New Jersey, was with me during the year, mainly as assistant in the work of the State Entomologist, but also engaged as an aid in the mosquito investigation. He made many interesting collections, and as an example of the possibilities of municipal work I had him make a survey of the city of New Brunswick, locating on a map all the places where he found mosquito breeding places, together with suggestions as to how each place should be dealt with.

Beginning June 20th, Mr. Otto Buchholz, of Elizabeth, New Jersey, began a series of collections, near his residence on Adams avenue, to determine the species of mosquitoes that occurred during the summer. Collections were made both indoors and out, at about five-day intervals, and on a subsequent page will be found a list of his captures, which is interesting and suggestive.

Personally, I have been in almost every part of the State, have consulted with improvement societies, or their representatives, have suggested lines of work for local bodies and have made inspections, where it was necessary, to arouse interest and give information. But my principal line of work has been in connection with the salt marsh or shore mosquito, which, whatever may be the case elsewhere, is likely to make local work within its range unsatisfactory and only partially effective. Its range this year has not been exactly the same as it was last year. In 1901 it was the dominant species at New Brunswick for weeks at a time, and my garden was so full of specimens that, when evening approached, it was an unpleasant place to remain in. In 1902 there was not a day when this species was troublesome; it was never the dominant species and very few specimens were in the garden.

A record of what I have learned about this species during the season is presented on a subsequent page of this report. One of the collateral results of my own work was the engagement of Mr. H. H. Brehme, of Newark, to make a survey of the Newark meadows, and during the six weeks many important facts were learned that will have a bearing upon the practical work of dealing with this species. At Elizabeth an organization had been formed to fight the local mosquitoes; but

Dr. Wm. F. Robinson, who was in charge, recognized so well the importance of the salt-marsh form in the problem, that he secured the appropriation of a sum sufficient to keep Mr. Brehme in the field two weeks longer than would have been otherwise possible.

The results of Mr. Brehme's work are also presented herewith.

Altogether, something over twenty species were bred, and, so far as collections go, there are only three species of mosquitoes taken in New Jersey whose larvæ are unknown to me.

A discussion of the resnlts obtained from observations on other species than *Culex sollicitans* mnst go over until a future date and for a final report.

Observations on the Salt Marsh Mosquito.

The observations made on this species during the summer of 1901 left no doubt in my mind as to its importance in the general problem. With this insect removed, the seashore would be practically free from mosquitoes; and not the shore only—the pines for miles back would be freed, and the shore area would be increased in value by many millions of dollars. It seemed a stupendous task and beyond all reasonable hope of attainment; but the estimates were formed on beliefs rather than facts, and my task was to discover the facts.

First of all, the winter home of this marsh species was unknown, and while it was assumed that hibernation was in the adult stage, no one had actually found the species. So, on April 4th, I sent Mr. Dickerson to Anglesea, with instructions to hunt mosquitoes in all sorts of likely and unlikely places, but to find the adult if it existed. Anglesea was selected because I knew the place thoroughly, knew many of the people, knew that there had been many specimens during the summer of 1901, and knew that I could get access to cellars and outbuildings.

During the afternoon cellars were examined and storerooms under club-house, etc. The results were twenty-six *Anopheles maculipennis* and four *Culex pungens*. The bathing pavilion and the area underneath it yielded nothing. Next day a vacant house netted thirty-five *Anopheles maculipennis* and nothing else. On the bay side of the island wrigglers were found in salt pools at the edge of the meadow, under shelter of a high bank covered by trees and shrubs—a warm corner, sheltered from cold winds. The larvæ were in various stages of development, but some of them were very small, as though recently hatched.

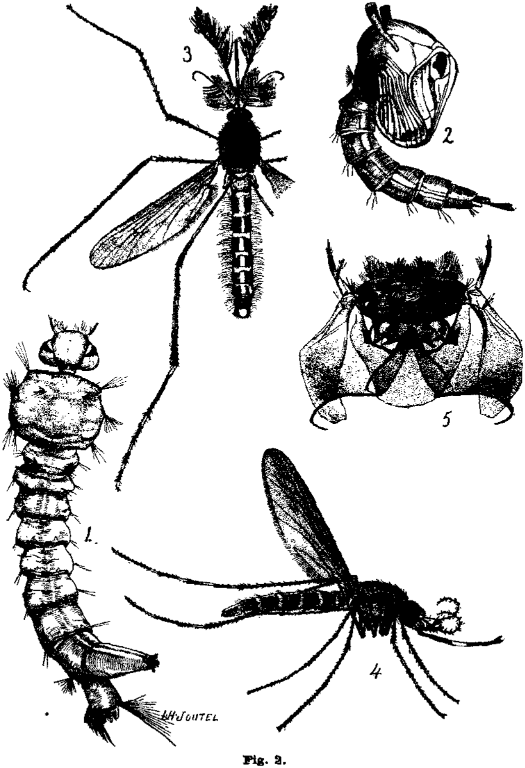


Fig. 2.

The Salt Marsh Mosquito, *Culex sollicitans*: 1, larva; 2, pupa; 3, adult male from above; 4 adult female from side showing the banded beak and legs; 5, head of larva; all greatly enlarged. From an original drawing by L. H. Joutel.

The results of the trip were not satisfactory, and on the 11th Mr. Dickerson again spent a day at Anglesea, this time hunting in the woods, in hollow trees, under bark, under overhanging banks, logs and natural shelter of every description. Attempts were made to start adults among the tall grass and from other conceivable places of concealment along and near the edge of the meadows. All without results, since not a specimen of *sollicitans* could be found. But a lot of larvæ was brought up, from which *cantans* and *sollicitans* hatched, in almost equal numbers, between April 14th and 21st.

The pools from which these larvæ were taken fill up only in very high or storm tides, and evaporate and fill up as it rains or shines, the water ever becoming less salty until another tide comes over it.

April 19th and 20th I spent at Anglesea myself, and not far from the hotel found a pool just beginning to dry up and already swarming with larvæ; another, not far off, was in the same condition, but here the larvæ were very minute—not over a day or two old. Searched closely for egg-boats or traces of them and for adults that might have been parents to the recent larvæ, but fonnd nothing. Tramped over a large marsh area, finding no larvæ in ditches or salt ponds. In one area of very wet meadow, with little holes, two-thirds of an inch in diameter and as deep, I tried dipping out one of the holes, and, to my surprise, found larvæ. Every little hole over this entire area had a few wrigglers as inhabitants. One fact forced itself upon me: no deep pools, even if completely shut off from the tide, had any larvæ of any size. Not until the pools began to dry up did the larvæ make their appearance. Those that were nearest dry had the largest wrigglers; those that were but recently cut off and only a little dried out had the babies.

The apparent suggestion was that it was a matter of temperature, and that eggs would not hatch until a certain degree of warmth existed; but that, again, meant that the eggs were under water, ready to be hatched, and must have been there all winter. This was contrary to all the books, and could not be too hastily accepted; but, at all events, the matter of temperature could be approximately determined. The only thermometer available was a cheap affair, in the ordinary tin casing, and it may have been off to some extent; but the results have a comparative value at any rate. The temperature of the air at 9 A. M. was 48°; temperature of sea water, 50°; temperature of the salt pools from which the larvæ were taken was 52°;

temperature of the old salt pools where the larvæ were taken on the 11th and were now most advanced, 55°.

Fresh water temperatures taken during the morning in ditches and wood pools was 52.5° to 53.5°. In one case, in a rather large swamp area, it dropped to 50°. Not a larva was found in any fresh water body that morning. In the afternoon waded into a flooded meadow area in front of the railroad station and found larvæ everywhere; also one pupa. This meadow slopes naturally toward the seashore, and in cutting and filling the streets a large tract sloping to one corner was left without outlet.

It was entirely dry in the fall of 1901 and did not fill until winter was well advanced. Then it became all flooded, served as a skating rink during the winter and as a boating pond earlier in the spring. It was never tide-filled, and the water, when I tasted it, seemed entirely fresh. Drying up had begun, and over a large area there was not over an inch of water.

I made a very close search for adults near and under the bathing pavilion, but found none.

From the pupa brought home by me, *Culex sollicitans* emerged, and April 25th sent Mr. Dickerson down to make thorough collections from this body of water. He brought back a large lot of larvæ and pupæ, and from all of these *sollicitans* was bred. Mr. Dickerson reported the meadow as drying up fast and that, as the water receded, the larvæ became more crowded and seemed comparatively more numerous. All the salt-water pools were now filled with larvæ, and five bottles of wrigglers were brought back from as many different areas. *Sollicitans* only was bred from all the bottles, and it was certainly established that salt water was not essential to its development. Absolutely fresh water did just as well. Moreover, as this area was dry for some time after the mosquitoes had disappeared for the season, and none of the pests having been found before the larvæ made their appearance, it seemed almost certain that the eggs must have been there before the water covered the ground; in other words, the eggs are laid on dry sod land and hatch only when covered by water of a temperature some degrees above freezing.

Breeding being now fairly started, matters were left until well along in June, because of a press of other duties. June 14th, spent another day at Anglesea and, in company with Captain Hankins, investigated a portion of the salt meadow area lying between five-mile beach and the mainland. To my very great surprise, found that

this area is really very well drained, very flat and swarming with fiddler crabs. Salt ponds in plenty; some deep, some shallow; but fish in all of them and not a mosquito larva. Captain Hankins tells me that much of the salt marsh area is exactly like this, and, during the four hours or more that we rowed through creeks and tramped over suspicious sections, not a wriggler was seen. Many miles of this meadow land will need absolutely no treatment whatever, and breeds no mosquitoes. From hour to hour the conviction grew that, were the broad meadow itself the only area to be treated, the matter would be very simple.

On returning to the hotel from the pier, noted a small duck pond filled with larvæ, and on both sides of the road tide pools, now drying up and absolutely swarming with larvæ and pupæ. Males had just begun to issue and they rose in clouds from the grass at the edge of the pools, but, of course, could not bite. No females seemed to have issued as yet. In this series of pools, the largest not over fifteen square feet in area, hundreds of thousands of larvæ were developing; more than were on the entire square miles of marsh area I had covered that day. A few quarts of kerosene would have killed the whole brood in a few hours; a few loads of sand from the adjoining sand hills would have permanently cured the whole matter. I called the attention of the mayor of the town and of the proprietor of the hotel, not over 100 yards way, to this condition of affairs. The former expressed great astonishment, the latter great disgust; neither of them did anything else, and that series of pools continued to develop mosquitoes throughout the summer.

On the evening of the 14th met with a number of persons interested, in Cape May, at the Marine Villa, by invitation of Mr. John M. Rogers, who has urged measures for mosquito destruction or control for years past. Mr. Frank M. Jones, of Wilmington, Delaware, was also present as the guest of Mr. Rogers, and informed me that he had made a preliminary survey of the territory, finding very little that could be considered dangerous, and a very few larvæ.

A very superficial examination of the surroundings was made on the 15th, and from what appeared, Cape May City can very easily rid herself of all local breeding places with little trouble and expense. There is a rather extensive swamp between Cape May City and Cape May Point, near the light-house; but it was very dry at that time and very difficult to say what this place would do in a wet season or when overflowed by a tide. The region toward Sewell's Point is said

to be a great mosquito-breeding country, but I did not get to this place at all during the season, though I intended to do so.

June 20th, saw Mr. A. V. Dayton, then Superintendent of the West Jersey and Seashore railroad, at Ventnor, and looked over with him some of the ground between Ventnor and Longport, where mosquitoes become very numerous and from whence they sometimes get into Atlantic City. I was able to point out to Mr. Dayton how, sometimes, *"improvements" created breeding places* by leaving low areas without outlets through street or road fillings or railroad dams. One especially bad area had been made so by filling in a street which cut off the access of tide-water that had previously reached it. Mr. Dayton promised co-operation by the railroad company in the general aims of the work, and it was at his suggestion that Special Bulletin T was prepared. Nearly or quite 100 copies of this Bulletin were sent to division superintendents for distribution among those in charge of the right of way, with instructions to abolish mosquito breeding places, so far as possible, whenever such were found.

The line of work now being done at and near Atlantic City is fast doing away with mosquito-breeding places at the edge of the marsh, but some bad areas are left and others are created through ignorance of the conditions which favor the development of these insects. It is believed that a careful survey of this area, pointing out the conditions that favor the breeding and the dangerous area, will result in the rapid improvement of those conditions and the removal of the dangerous area.

Early in July, having decided, from the evidence obtainable, that *C. sollicitans* has altogether different egg-laying habits from those described for *C. pungens*, I planned a campaign at Anglesea that should result in answers to the following questions: 1. Where do these mosquitoes lay their eggs? 2. How long does it take them to get ready to lay? 3. How many may one individual place? 4. Is it necessary for the female to feed before she is able to oviposit?

A series of seven tubs was sent to Anglesea from New Brunswick; Mr. Dickerson went down July 7th and I followed later in the day. The tub experiments were assigned to Mr. Dickerson, while I conducted a series of marsh explorations.

Mr. Dickerson's record is essentially as follows, up to the time that I left him in charge: Placed the seven tubs in the backyard of the Keystone Rod and Gun Club house so that only a few inches projected above the surface. In one tub put a few inches of salt water

only and in a second some sod from the salt marsh, covered by two or three inches of salt water. Mosquitoes were very abundant here, and the tubs were left uncovered, to see whether any mosquitoes would oviposit in them. As breeding pools were rare at this time, it was hoped that these tubs would be very attractive. In a third tub sod was placed, with just water enough to keep it moist, and in all the others the bottom was covered with sod, and salt water, to cover well, was added.

Several jars of larvæ were collected in the afternoon, and in the evening a few mosquitoes were collected and placed in a jar, with a little water and some grass, to see if eggs could be obtained in that way.

July 9th, placed a jar of larvæ in each of the covered tubs containing water-covered sod, that the adults, when they issued, might have opportunity for oviposition if they so desired. In the afternoon experimented with Chloro-naptholeum on *sollicitans* larvæ. Four quart jars were more than half filled with decidedly brackish water and all were well stocked with larvæ. With a medicine dropper put in two, four, six and eight drops, respectively. An hour later nearly everything was dead in the jars containing six and eight drops; in the jar with four drops many were dead, and in that with two drops a few were gone. In this diluted sea water the Chloro-naptholeum forms a film on the surface, which drives the larvæ down when they attempt to pierce it. A few young fish and water boatmen in one of the jars were also affected. Yet an hour later everything was dead in all jars, except for one or two larvæ and some other creatures in the jar containing two drops. In the evening mosquitoes were collected in a jar and placed in the tub containing only moistened sod, that they might oviposit on it if they would.

July 10th, secured additional material for experiment, located several new breeding pools and sprayed two pools with Phinotas oil, very liberally applied. Two jars with pupæ were prepared, to test the comparative value of Chloro-naptholeum and Phinotas oil, and five drops of each were used. The Phinotas oil also produced a surface film, but did not make the water milky. Next morning the pupæ in both the jars seemed very little affected, and that was the case in the sprayed pools, from which adults were now coming in great numbers. Next day the pools had dried completely and the breeding pools were everywhere disappearing, layers of dead larvæ and pupæ being left on the surface mud in many cases. One matter was very

definitely proved at this time—neither larvæ nor pupæ bury themselves in the mud as the water evaporates. When the water disappears they simply die, no matter what stage they may be in. To determine whether eggs had been laid in the water some of the surface mud from the recently-dry pools was obtained, part of it placed in jars and covered with water, and part was taken to New Brunswick and washed out in the laboratory; no eggs being found nor larvæ secured in either case.

On the 12th I left Mr. Dickerson in charge, and he carried on the experiment by keeping up the mosquito supply in the tubs, placing food in some and leaving others bare and whatever else was necessary.

Mosquitoes were also captured and confined in jars, with soil, with water, with tufts of grass and without any addition whatever. In almost all cases eggs were obtained without any trouble, and appeared on the leaves, on the ground, on the grass blades below the surface of the water and even on the bare glass. The insects were simply ready to lay and placed the eggs anywhere; usually they were black, but white ones also were laid in some places.

These eggs were left in the jars, some covered with fresh and some with salt water, some jars kept indoors and some outdoors under natural conditions; but in no case did they hatch while under observation—a period of four or five days.

July 15th, Mr. Dickerson sent me up some eggs obtained in this way, and also a few adults, of which five were dissected, with the following results:

No. 1.	Black eggs	46	......
	Gray eggs	17	......
	White eggs	101	164
No. 2.	White eggs only,	......	117
No. 3.	Black and gray eggs only	......	148
No. 4.	White eggs only	......	135
No. 5.	Black and gray eggs	47	......
	White eggs	35	82

As to No. 5, it was quite possible that it had already deposited part of its eggs. It is noteworthy, in view of what appeared later in the season, that at this time there was no difficulty in getting any desired number of gravid females.

July 16th, all breeding pools were practically gone; in the grass was a lot of old adults and a vast swarm of recently-developed forms, male and female; on the evening, with a west wind, the hotel porch

and the beach to the water's edge became overrun with them. As the same wind continued next day, matters became much worse, until the whole shore area became filled with specimens.

July 18th, I reached Anglesea again myself, and on the 19th all the tubs were overhauled and Mr. Dickerson's observations collated.

The uncovered tub, No. 1, was kept with from one to three inches of sea water during the two weeks that it remained in the ground. *No larvæ developed at any time and the water remained clean.* It was always cooler than the water in the surrounding pools, but was always warm enough for mosquito development. On the 19th found a little group of ten or twelve eggs at one side of the tub, near the surface of the water, and they seemed to be of this species. Nothing was in the water itself. In view of the fact that mosquitoes were very abundant in this place and that they had had two weeks in which to oviposit, it would seem to be a fair conclusion that eggs are not laid in permanent, open bodies of water. This is borne out by the fact that I have never found larvæ in pools with clean edges and without vegetation. There are many such ponds and pools on the salt meadows and they may in general be accounted safe. So, on sand flats and mud flats, I have frequently seen large areas of shallow water, in which no trace of larvæ was found. The eggs found in this tub were placed in a cup of water, but were afterward mingled with others obtained under natural conditions, so I cannot tell whether these hatched. The eggs sent to me at New Brunswick had tended to split and break after three or four days, as if the contents had fermented and burst their envelope.

The second exposed tub was bottomed by mud-covered sod, flowed by an inch or more of salt water, and this was intended to represent a grassy pool. The water evaporated pretty close to the surface at times, but it was never allowed to go quite dry. No eggs were noted in this tub at any *time, and when the whole matter was dumped out* and examined on the 19th, neither larvæ nor eggs were to be seen. No natural breeding pools were near by at the time, and if that sort of locality is favored, this would have been an ideal place. Nevertheless, after two weeks, not a wriggler was found in the water, every particle of which was closely examined and not an egg was found on the grass, almost every blade of which was examined with a lens. It would seem to follow from this, added to observations made at the edge of the marshes, that the insects will not oviposit in any water-covered areas.

Tub No. 3 was covered with mosquito netting and had a bottom layer of sod, which was kept moist. A jar of mosquitoes was collected July 8th and turned loose under the netting. It was noted at the time that all were females and that many of them had the abdomen fully distended as if by ova. Adults with fully-developed ova were collected a day or two later from the same area, hence this point may be considered as beyond reasonable doubt. July 14th, the mosquitoes were dead, and salt water was added until the sod was covered. This tub was intended to imitate a moist marsh area, in which mosquitoes had an opportunity to oviposit, and when the water was added the eggs, if any were laid, should have an opportunity to develop. On the 19th no larvæ were found in the water and no eggs were found on the sod. I cannot quite explain this failure to find eggs at any rate, unless they went to pieces, like those in the jars. In view of what was later found, the indications would seem to be that the eggs need a certain period of drouth, during which development takes place, and that if they are water covered too soon after they are laid, they burst.

Tubs 4, 5, 6 and 7 were all covered with mosquito netting, all had sod bottoms and all had water enough to cover the surface. Live mosquitoes were placed in each tub, and also a jar with numerous full-grown larvæ and pupæ. No definite information was gained from these tubs, all of which were bare of either eggs or larvæ when examined.

All the indications pointed now to eggs laid dry in mud or sod and, first of all, samples were secured from the bottom of a pool that dried out a week previously, after having matured a large lot of mosquitoes. The soil was sandy, with a crust of organic matter about one-sixteenth inch thick, which tended to become dry and leathery. No eggs were found in this. From another pool other samples were washed, and dead larvæ and pupæ were floated out, but no eggs. Then sent Mr. Dickerson to cut out a section of sod from an area where we had found mosquitoes abundant on the 8th and 9th. This was near a pool that dried up completely on the 11th, but the area from which the sod came was already well above the water line on the 8th, and had certainly been dry at least several days before. The section brought in was about four inches square, was moist, the surface mud covered, and, when I examined the edges with a lens, I at once found the eggs imbedded in it. The mud was about one-fourth inch thick, the grass was very dense, and below the mud was a tangled mass of root fibres, like green turf. A small portion of this

surface was washed out and eggs were found in it in such numbers that there could be no doubt that this was their natural home. When they were deposited there, could not be even approximately determined. Gravid females were there on the 8th, but they might have been there long before, and what eggs were obtained from those taken on the 9th failed to develop larvæ.

Having determined the presence of the eggs in some number, I cut the grass close to the surface and washed the mud into a granite basin until the tops of the grass roots were washed clean. The basin, half filled with fresh water, was left until the mud settled a little, to make sure the eggs did not float, and was then placed on a table in the club-house at 9 P. M.

I should have said previously that, by the courtesy of the members of the Keystone Rod and Gun Club, of Philadelphia, these experiments and investigations were carried on at their club-house and in the grounds surrounding them. I take this opportunity to acknowledge the courtesy and to express my gratitude and appreciation for the assistance rendered.

Next morning, at 8 A. M., the granite basin was swarming with wrigglers. We made no serious effort to count them, but there were 300 certainly, and perhaps 500.

Two sods were cut on the 21st, from the same general area where the eggs had been found, and these were carried to the laboratory, where one was placed in a large dish containing an inch or so of water, that it might be always thoroughly moist or even wet, yet the water was never allowed to come so near to the mud surface that eggs could fall into it or larvæ hatched in the wet mud would be likely to reach it. The other was placed in a large, porcelain, evaporating dish, so that air could circulate all around it, and no water was added so long as it remained there. The fortunes of these sods will be followed on a later page.

On the 18th and 19th collected a large lot of mosquitoes for examination, at the hotel porch and in the grass around the old pools, and did not appreciate, until later, that I had in view the end of one brood and the beginning of another that was destined to represent the species at Anglesea for several weeks before there could be local additions to it. Gravid females were already present on the 8th, and on the 18th they occurred in the same places—worn and battered examples, low down in the grass, caught only by sweeping closely in the early evening.

On the 8th, also, we found a new brood coming out from the fast-diminishing pools, and thousands of males were seen. On the 19th no more males were found; but the fresh females swarmed in the grass and came to the hotel porches in great numbers. Not one of these females contained even a trace of ovarian development. The males were gone; it is fair to assume that they fulfilled their purpose in life before disappearing; but it is equally certain that of all the flying swarms that were ready to attack none was in position to oviposit. There was not even a trace of an enlargement of the ova in the ovarian tubes.

Of the material collected in the grass over 100 specimens were examined and the developing ova were counted. In stages of development they ranged from half to full-grown eggs; the latter from soft white to gray, translucent. In number of ova the range was from 75 to 200, with an average of about 175. It was a notable fact that in the great majority of cases obvious remnants of blood food were found in the alimentary canal, where the ovaries were well developed. So general was this that the exceptions were considered as cases where the material had been so completely absorbed or excreted as to make its recognition impossible to ordinary examination.

While Mr. Dickerson was arranging for the details of the tub experiments, I explored some of the marsh areas, with Mr. Richard Button as boatman and guide. On the 8th rowed through Beach creek to Wildwood and then across to the marshes basing the upland. Landed at several points and from the boat examined the flat lands. Tramped about a mile of marsh to the upland, diverging wherever pools could be seen. Everywhere there were fishes, large and small, fiddler crabs and other creatures, but nowhere any mosquito larvæ. Nor were any encountered until the land began to rise and we were beyond the range of the ordinary monthly high tides. When we reached that point some mosquitoes began to rise in the grass in front of us, and in a little while I began to find larvæ in the holes filled with water, where there were no fish nor crabs. As soon as we struck the real upland everything was full of mosquitoes, and I found that every little hole, every pool and every little run that came into the marsh had its wriggler fauna. The rise here is rather sudden, and the line between mosquitoes and no mosquitoes is sharply marked. The number of breeding places in this area is rather small, and there would be little difficulty in draining this so as to get rid of all these pools at the edge of the upland. The interesting and important result

of this trip is a confirmation of the conclusions reached in June—that the salt marsh area, as a whole, is not to be considered dangerous as a mosquito breeder. No salt pools free from vegetation contained any mosquito larvæ. Nowhere on the marsh, within the range of the tide, did mosquitoes occur in the grass in any number, and nowhere in any of the channels running through the marsh was there any trouble with them.

July 9th, we rowed over to Seven Mile Beach and landed on the bay-side, a little below the life-saving station. Crossed the marsh to the high, middle ridge and to the shore, noting nothing that was new. A very large pool had been left by a high tide in a sandy basin, and this was slowly evaporating; but it contained no wrigglers. This was expected, for the insects do not oviposit on bare sand.

At the life-saving station, Captain Ludlam, who was in charge, said that mosquitoes were never very numerous to the south, but came from the west and went northwardly, while the woods toward the bay-side were always full of them. Crossed this woodland, which more than justified what had been said, and beyond it found a circular, depressed area or basin 200 feet or more in diameter, with from one to three inches of water, in which grass was growing everywhere. The water was lukewarm and was actually alive with wrigglers and their pupæ. Adults, too, were swarming, and, altogether, a more ideal mosquito breeder it would be impossible to imagine. The water was salt as the sea itself, and was undoubtedly tide-water, with very little addition from springs in the woods above, which did not furnish enough to prevent its gradual drying up. The place is completely cut off from ordinary tides; sand hills, ten to fifteen feet high, surround it almost completely, and to the east they are tree-covered. Toward the west, or bay-side, is an opening in the hills, forming a bar about one foot above the general level of the basin. Over this bar the tide gets in when the whole marsh is flooded, and on such occasions very few fish seem to be carried up so high. Literally, millions of mosquitoes had hatched and would hatch from this area, and, with a southwest wind, would fill Piermont, Stone Harbor and Seven Mile Beach in general; with an easterly or southeasterly wind they would drift to Cape May Court House and other places on the peninsula. This is one of the places from which come the great clouds of specimens that fill the pines and the Sonth Jersey region in general. A ditch through the dam closing this basin, draining it to the general salt marsh level, would cure this place at once;

and such places as this must be sought out and cured to free South Jersey from the mosquito pest.

July 10th, rowed to Shell Beach Landing, toward Cape May Court House. Explored the marsh to the upland, aud found this to be the best natural gradation into upland that I had seen. The marsh is very level, and where it begins to rise above ordinary high tides, salt hay may be and is grown. From the edge of the marsh to the base of the upland few mosquitoes were found, and no larvæ were in the pools, which mostly contained fish. Along the upland some mosquitoes were encountered, and, in a deep ditch made to get material for a road, found plenty of wrigglers. Had some conversation with one of the oystermen, who tells me that the monthly high tides cover the marsh completely to the upland, except in August and early September. The last tide had occurred on the 7th or 8th of July, and this would not be equaled again until late September or October. All the pools left by this last tide contain minnows, but these would die in about a week, when the pools dried up, and then, when it rained and filled the pools once more, they would be full of wrigglers and would swarm with adults. This is practically what Mr. Seal has claimed for certain species at Delair, and it is in accord with the observations made by myself.

The three days on the marshes of this area proves very conclusively—*first,* that by far the greatest area of salt marsh land between the edge of the mainland and the edge of the islands lying parallel to the coast is not and cannot, under ordinary conditions, become dangerous from the mosquito standpoint; *second,* that wherever the little species of minnow (*Fundulus*) can maintain themselves from tide to tide no mosquitoes can or do breed; *third,* that the breeding places are at or near the edges of the upland, where pools are left which the low, summer tides do not reach; *fourth,* that the first breeding places of spring are those areas very high up, covered only by the highest winter tides, which warm up early and bring to maturity a brood from the eggs that had wintered over.

It has been recorded that on July 21st two sods were gathered on the meadows at Anglesea and brought to New Brunswick.

July 31st, cut off about two square inches of the sod that had been kept dry, washed the top layer of soil into a glass dish by means of a pipette and left it over night. August 1st, Mr. Dickerson counted 117 young larvæ. Growth was slow, perhaps because of lack of food and fresh water, and on the 11th put in a bit of salt sod, about which

all the surviving larvæ at once grouped themselves. August 12th, first pupa; August 13th, three more pupæ; August 15th, several more pupæ and one male adult—*Culex tæniorhynchus.* About a dozen adults were bred from this lot and every one was *tæniorhynchus.* In view of the fact that nothing but *sollicitans* adults occurred where these eggs were taken, this was rather startling!

August 10th, cut off about one square inch of dry sod, rubbed it up in fresh water in a glass dish, and left it there just covered. At 10 A. M. a dozen or more wrigglers were already hatched and moving about in a most lively fashion. As I was desirous only of testing the vitality of the egg, I did not carry further, but placed the larvæ in alcohol.

August 10th, cut off about two square inches of the wet sod and placed it in a dish, just covered with fresh water. At 9 A. M., fifteen minutes later, saw two eggs floating on the surface. Next morning no larvæ had developed, so the sod was cleaned out, and in the mud Mr. Dickerson found a few eggs and many egg fragments. It is obvious that the eggs were there sure enough; but that something hindered their hatching.

August 11th, cut off two square inches of wet sod and washed off the surface into a glass dish at 7:30 A. M. Four eggs floated to the surface during this operation. Next day there were more floating eggs, but no traces of larvæ.

August 12th, 8:45 A. M., Mr. Dickerson washed off a small piece of dry sod and began collecting the eggs for preservation. At 9:15 A. M., just half an hour later, he reported that larvæ were beginning to issue, and I had an opportunity to see the pure-white wriggler just out of its shell. About one-fifth of the egg lifts off and folds back, as if on a hinge, giving the little larva a chance to work out.

Placed the piece of sod that had been washed into a large dish, and in another hour had more little larvæ, which, again, were not bred.

August 25th, placed a piece of dry sod in salt water from the Newark meadows at 10:15 A. M., and at 12 M. larvæ began to hatch. Quite a fair lot of them was obtained, and pupation began September 4th. The first adults issued on the 6th, and on the 9th, when the culture was closed, I had a dozen adults—all *tæniorhynchus*—and as many larvæ and pupæ.

Other small pieces were taken from the dry sod, from time to time, and some were given away; in every instance larvæ were obtained in a short time, but none were bred to maturity.

From the wet sod similar fragments were taken, and in all cases the results were negative—*i. e.*, no larvæ hatched, though in every instance floating eggs were seen.

September 21st, placed the entire remnants of the wet sod in a large dish and covered with water. Next morning, to my surprise, a number of larvæ was observed, and on the 25th fifteen examples were transferred to a small dish containing clean water and a piece of fresh sod. This transfer became necessary, because the old sod was getting very foul and the larvæ were dying off. On the 29th the first pupa formed, and October 1st there were six more pupæ and three larvæ. October 2d, there emerged one male *tæniorhynchus,* one male *sollicitans;* October 3d, two female *tæniorhynchus;* October 4th, one male and one female *tæniorhynchus* and one female *sollicitans;* October 5th, one female *sollicitans.* In all, eight specimens, of which five were *tæniorhynchus* and three were *sollicitans.* If we have two species, their eggs were mingled in the same sod, and the larvæ were so nearly alike that no differences were noticed. The surprising thing was that any egg should survive so long a period on a soaking wet sod!

October 4th, placed the balance of the dry sod in water, to which a little sea salt had been added. This was done at 10:50 A. M., and the sod was so dry that it was necessary to weight it down to get it covered by the water. At 1:30 P. M. little wrigglers were in the water, all around the edges of the turf, and next day over 100 specimens were actually counted.

On the 8th, as the water was becoming foul from the old sod, transferred about 150 larvæ to clean water, to which sea salt and a piece of broken-up sod had been added. There was at this time a great difference in the size of the larvæ, indicating a very unequal rate of development.

About this time there was a cold spell, and as there was no heat in the laboratory during the night, growth was very slow and the water tended to become foul. Finally, on the 24th, sixteen days after they were hatched, the larvæ were yet scarcely half-grown, many had died and the remnants were bottled; and thus closed a very interesting experiment, by which it was, for the first time, definitely proved that species of the genus *Culex* lay their eggs singly, in dry or most soil, and that for months they may lie thus, ready to hatch when covered by water of a proper temperature.

Incidentally, the same points are proved for *Culex tæniorhynchus,* assuming that it is really a distinct species.

July 21st, I spent a few hours at Avalon, with Mayor Gilbert S. Smith. The conditions there are not essentially different from those existing at Five Mile Beach, save that there is more opportunity for breeding at the base of the upland; but, on the other hand, tide ditches come to this point, so that drainage into the level meadow will not prove a serious task. All the specimens collected here were such as came to bite, and of these not one had any appearance of developing ova—all were fresh, clean specimens.

August 4th and 5th, was at Beach Haven and examined rather carefully the conditions existing in that immediate vicinity. Did not get north of Barnegat Junction; but south of that point to Beach Haven, and for some distance south from that, breeding places can be completely abolished at very little trouble and expense. The island is very narrow and the marsh area on the bay-side is low, so that even shallow ditches would carry tide-water to the edge of the upland. There is a little series of hollows, made by street and road fillings, which can be very easily filled or drained. It had rained heavily just before I got there, and yonng larvæ were in all the recently-covered areas. It rained very heavily during one night of my stay, and the next day, wherever there was an inch of water in the meadows, it was swarming with little wrigglers. In the early afternoon much of the area had dried up completely, and the wrigglers were dead, of course—more millions having perished in this way than survived. Where the water had been deeper the larvæ were now much more crowded, as evaporation at the edges drove them to the centre. Had there been a week of wet weather this entire brood would have reached the adult stage.

One lot of twenty-eight mosquitoes was captured in the evening as they came to bite, and one of them succeeded in getting a full stomach before I bottled it. None of the specimens had the ovaries in the least developed.

Another lot of twenty-three specimens was captured at the edge of the marsh land, and of these ten had had a full meal of blood. All save one had undeveloped ovaries, and in that one the eggs were half-grown or more and remains of blood food were evident in the alimentary canal.

The observations made here supplement those made during 1901 at Seaside Park, and show that eggs are everywhere on the lower meadows, and that, wherever the mosquitoes may be in swarms, there they will oviposit. Millions of eggs never hatch at all; other millions

hatch, as did those above mentioned, when rain comes, and perish within a day or two when the water dries off.

August 15th, I was at Lahaway and found everything swarming with *sollicitans*. During two or three days of collecting, Mr. Brakeley and myself found the larvæ of five species of mosquitoes, the adults of which were so scarce as to be hardly noticeable; but not a larva of *sollicitans* was found. A few days before my arrival Mr. Brakeley had collected ninety specimens which came to bite while he stood quietly a few minutes, and these I examined later. Only two of them had succeeded in getting blood, and none of them had developed ova.

I captured 253 examples by sweeping in the grass to make sure of getting gravid females if such there were; but though eighteen examples had feasted upon blood, not one showed any ovarian enlargement. Nor did I captnre or see a male during my stay.

August 28th, went to Tuckerton from Philadelphia, and at Whitings *sollicitans* began to come into the train. Before we reached Manahawken it was a nuisance, and thence, to Tuckerton, from half a dozen to a dozen specimens were around almost every passenger. Drove to the edge of the marsh, abont six miles from town, and mosquitoes were abundant everywhere. While my driver was explaining to me how sensitive he was to mosquito bites and how much he suffered from them, a specimen alit at the edge of his lower lip, gorged itself with blood and flew away, the speaker remaining completely unconscious of the curious contradiction between his statement and the actual fact. Clouds of mosquitoes arose at the edge of the marsh, and other clouds arose at every step on the way to the De Mott oyster-house, where Dr. Nelson was carrying on his oyster work. About an hour was spent here in collecting, and it was notable that not a male was seen; furthermore, the females had a rubbed and faded appearance, as if they had lived a long time. There had been no rain for some time, and, according to Dr. Nelson, the marsh was drier than it had been at any time during the summer. Only tide-water was found, except a few pools swarming with fish. Twenty-four hours more without rain would dry these pools and kill the fish, leaving excellent breeding places after the next rain. This is a very low, soft marsh, not much above ordinary high tide, with many depressions and holes in which water will stand. Wagon roads lead across it in several directions for carting salt hay, and in these roads wrigglers swarmed earlier when the marsh was wet. Dr. Nelson says that he has crossed this marsh when every hole was full of water and every

pool of water was a mass of wrigglers. In the afternoon skirted the marsh in a gasoline launch with Dr. Nelson and Dr. Lightfoot, to the Mullica river, and afterwards up the Bass river, to the New Gretna landing. The whole marsh was swarming with mosquitoes and was of the same general character as already described; but everywhere the absence of males was noted. From the landing to the hotel at New Gretna was a walk of one and one-half miles through clouds of mosquitoes, and outdoors in the evening was unpleasant to say the least. Yet indoors mosquitoes were few and in the bedrooms none at all, though no especial precautions were taken. Drove from New Gretna to Pleasantville, a distance of sixteen miles, much of it along the edge of the marsh, through mosquitoes everywhere. This area at the mouth of the Mullica river is by all odds the most extensive breeding place I have found, and forms one of the main centers for the distribution of the insects to inland points. The few hours I spent here served only to bring out that fact and pointed to this as a place that must be thoroughly investigated when time and money are available.

One hundred and twenty-four specimens were collected on the marsh, and of these, 117 had neither food remnants nor developing ovaries; two had remnants of blood food, though no ova were obvious; one example had fed upon blood and the ovaries were developing, but the eggs could not yet be counted. In four specimens, in which no food remnants were apparent, the ovaries contained 17, 33, 105 and 113 full-sized eggs, respectively. Except in the last, the eggs were becoming grayish, translucent. I could not determine whether the females containing the small number of eggs had really developed no more or whether some had been previously laid.

Two bits of sod cut out of likely places in the meadow were placed in salt water before I left Dr. Nelson's quarters, but according to his report no larvæ had developed from them more than twenty-four hours afterward.

September 2d I spent at Newburyport, Massachusetts, and on the marshes along that coast, examining a ditching machine; this point will be again referred to, elsewhere.

September 3d, forty-two examples of *sollicitans* were collected for me at Anglesea, and none of these, when examined, showed either food remnants or growing ovaries.

September 11th, Mr. Dickerson went to Anglesea again, and on the 12th collected a series of twenty small sods from half as many differ-

ent places and tested small bits of them in tumblers before bringing them to New Brunswick. Positive results were obtained with eight sods only. There had been heavy rains a few days before, all the lower surface depressions were full of water and all were swarming with small larvæ. Hence, there had been a general recent egg-hatching in the best places.

It may be added here that, from the area where the sods turning out *tæniorhynchus* were obtained, nothing but *sollicitans* had ever been taken from the pools.

The sods were started September 14th, in small battery jars, and larvæ developed in six of them; but the water turned foul very rapidly and I lost every specimen before it became anywhere nearly full-grown.

Of the adults brought up by Mr. Dickerson, thirty-six specimens were examined, and of these twenty-three had undeveloped ovaries and empty crops; nine others had been fully fed, but were otherwise not different; one had a goodly remnant of blood food and half-grown eggs; while three others, though showing no blood remnants, had the ova nearly full-grown and very numerous.

At this time Mr. Brehme's collections were under way, and these are elsewhere reported upon.

October 19th, Mr. Brehme sent me two sods from the Newark meadows; one was taken from the area near Hamburg Place, where so many larvæ had been found; the other came from the Bound Creek district, where, also, larvæ had been numerous and where the meadow had since been burned over.

October 28th, a piece, four inches square, was cut from each of the sods at 11 A. M. and placed in a glass dish, with fresh water. No larvæ developed in either during the day, and next morning both were placed on a radiator, to try the influence of warmth. No better results were obtained in this way, and the effort was abandoned.

November 5th, what remained of each sod was carefully washed, so as to bring all the surface mud into glass dishes, and this material was carefully examined by Mr. Dickerson. Not an egg or an egg fragment was found in either dish.

October 23d, between 4 and 6 P. M., Mr. Dickerson collected 13 males and 119 females at the foot of Hamburg Place, Newark. A slight wind was blowing and the insects did not rise readily until dusk, when he saw them float with the wind for several yards before

attempting to alight. In three only of the females had the eggs begun to enlarge.

October 30th, another collection was made at the same place and sixteen *nigritulus* and forty-six *sollicitans* were obtained. None of the latter had developed eggs and only one had traces of blood food.

Points to be Investigated.

It will appear, from the previous record, that much has been learned concerning this salt marsh mosquito, and much yet remains to be learned. The inability to continue marsh investigations late in fall leaves it a little uncertain under just what conditions the eggs winter. Nor do we know what temperature will bring them out in spring. We know that eggs may lie dry and maintain their vitality for months, hatching within a few hours after they become water-covered; we do not know how long they must lie dry before they can develop if water-covered. We do not know how many broods of the species there are or, under favorable circumstances, can occur. The only period when gravid females were at all abundant was in early July; after that time not a female was found that had black eggs within the body. We do not know how many times an individual may bite, nor whether blood food of any kind is in any way essential to the development of the ovaries. We know that the adults live for weeks; but how long they must live before they can reproduce is yet in doubt. Nor do we know certainly whether all the eggs are laid at one time or whether oviposition extends over any considerable period of time. Of hundreds of females examined in the pines and from points remote from the shore not one had developing ovaries or fully-formed ova. It is scarcely probable that these examples are infertilized, because males are always present in abundance before any females issue. But why do they not lay eggs? The insects occur by the millions throughout the South Jersey swamps and woods; but though there is water in abundance, not a larva has ever been found. Yet the species can and does develop in entirely fresh water along the shore.

The economic bearing of some of these points may not be obvious at first sight; yet, if there is a weak point in the insect's life cycle of which we can take advantage, it will come in connection with the early broods, and the start they get in the spring, and we must know all about that.

Newark Marsh Investigations.

Toward the end of the season, when I felt quite certain as to the general habits of the salt marsh mosquito, I secured the services of Mr. H. H. Brehme, of Newark, a well-known collector of insects and for years a member of the Newark Entomological Society. His assignment was to explore the salt meadow area lying immediately to the east of the cities of Newark and Elizabeth, to determine how much of this land was actually dangerous as breeding ground for the *Culex sollicitans*. From August 19th to October 4th Mr. Brehme was almost daily in the field, and during that time explored most thoroughly the area between the south bank of the Passaic river and the north bank of the Rahway river, and from the Passaic river, Newark bay and Arthur Kill on the east to the highland on the west.

An area of almost twenty square miles of the most difficult territory was closely surveyed in this way, and the breeding places were fully mapped out on separate-sheet maps supplied by the State Geological Survey. A reduced copy of the completed map is reproduced here, to show graphically and at a glance how really small is the actual percentage of dangerous marsh. A closer study will show that many of these bad places lie along the edges of the highland or near to some of the small creeks that cross this marsh, forming natural channels, into which the wet marsh can be drained by cheap ditches.

To ascertain what mosquitoes were flying on the meadows and what species bred there, Mr. Brehme collected adults as well as larvæ, in alcohol, sending in over 200 vials containing many thousands of specimens. All of these were carefully examined by me in the laboratory to verify the species and to ascertain the conditions under which the insects would breed. Quart jars of live wrigglers were sent in two or three times a week from the surveyed areas, and hundreds of adults were bred in the laboratory. It is safe to say that every species that can breed under the marsh conditions was represented.

A few words as to these marsh conditions. Almost the entire area is subject to overflow at storm tides and every part of the marsh is salt. There are a few islands of highland noted on the map, and the actual eastern bank is rarely submerged. All the creeks are tidal and the water is always at least brackish. At the edge of the highland, springs and brooks of fresh water come into the marsh and freshen the creeks at low tide. After a period of low, summer tides

Fig. 3.

Typical breeding pools on the Newark meadows. The upper figure shows Mr. Brehme in collecting attire. From original photographs.

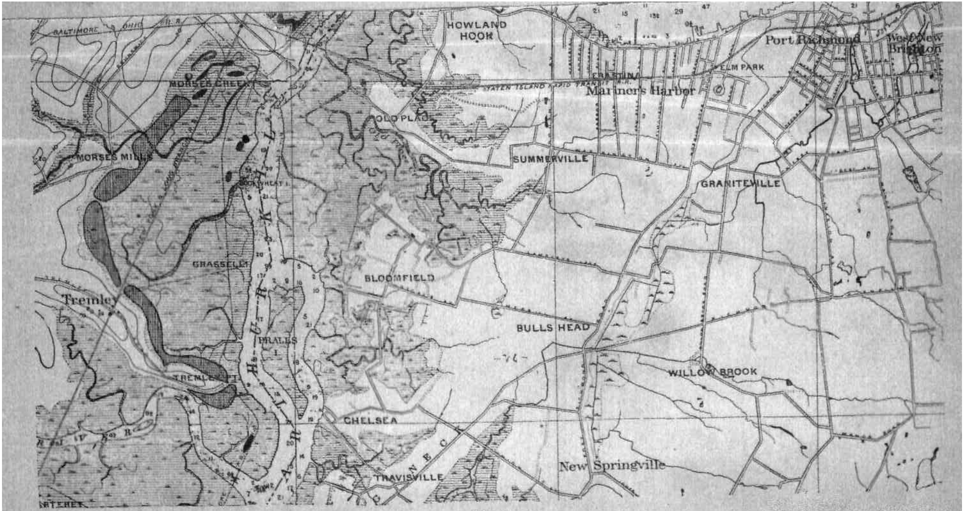


Fig. 4.

Map of the Salt Marsh Area from the Passaic River to Tremley, showing the places where mosquitoes breed. The salt marsh area is uniformly lined, parallel with the latitude; large breeding areas are cross-lined, parallel with the longitude; small areas or pools are solid black. Original.

the water and pools near the highlands is practically fresh. An east wind, with a high tide, may in twelve hours change the whole into salt or brackish water. There are large stretches of the meadow overgrown by cat-tails, six feet or more in height, so densely as to make it impossible to get through, and these generally stand in from one to six inches of water; but no mosquito larvæ have been found in such places by Mr. Johnson, Mr. Brehme, Mr. Dickerson or myself, and each of us have sought diligently and at various seasons.

High, level areas that drain completely after every tide that covers them are safe, of course; and so are those low areas that are covered at every tide, even if by only two or three inches of water. Too many natural enemies exist here to enable mosquito larvæ to exist.

But there are areas of what may be called rotten meadow—just above ordinary high water—full of holes and shallow depressions, where walking is unsafe, and where, except on grass tufts, the boot sinks from four to six inches, leaving a hole that fills at once with water. Extra tides flood these places in spring and leave considerable water areas; some with and some without minnows or "killies" (*Fundulus* Sp.). Wherever the fish occur no mosquito larvæ develop; where none are brought in the pool soon swarms with larvæ, and later adults come in great numbers. Usually a droughty spell comes in early summer, that dries up many of the more shallow pools containing fish, and, of course, kills them as well as any other aquatic animals living there. A heavy rain may fill these pools before another high tide comes in, and there now being no fish, the water soon swarms with wrigglers.

Characteristic mosquito areas and pools are shown at Figure 3, both from the Newark meadows.

Mr. Brehme's Report.

Mr. Brehme's report to me was made partly by letter, partly in a written statement and partly in conferences had with him. To keep the whole in consecutive form and to include the names of the insects taken and observed, his statements and suggestions are here connected and combined. The map (Figure 4) should be consulted in connection with this report.

August 19th, the Great Island area was visited under the impression that it was probably one of the pest-holes in the marsh, but the entire day's work yielded not even one mosquito larva, though adults

were present in large numbers. During that day, 169 small holes, 7 larger ponds and 11 ditches were examined, and, while a few small Hemipterous insects and some aquatic larvæ of Coleoptera and Neuroptera were found, not a wriggler was seen. The meadows here are low, are covered by even ordinary tides, and all the water bodies swarmed with "killies."

Only a few adults were taken, and of these two were *Culex cantans* and eight were *C. sollicitans*. Of the latter, four had not fed at all and the others had fed on something other than blood; in none of them were any ovaries developing.

August 20th, looked over a large area lying between Bound creek, the Pennsylvania railroad and Woodruff creek. There were not so many water bodies here and some places not within reach of the ordinary tides had dried up; others were very low, but everywhere there were "killies." Not a larva was seen or taken in this day's work.

Fourteen adults were sent in; of these only one had fed on blood, and in that one only were the ovaries developing.

August 21st, began at Great island and worked south to Elizabethport. Nothing was found north of Woodruff creek, though there were many pools to be examined. On the south side of Woodruff creek began to find pools containing larvæ, out of reach of tide-water. The samples of larvæ sent in proved, on study, to be *Culex nigritulus*, which, up to that time, had not been known to occur in this country.

Eleven adult *sollicitans* were sent in, and of these nine had the alimentary canal empty and the ovaries entirely undeveloped. One example had the abdomen distended by a blood clot; the ovaries undeveloped. The remaining example had nothing in the alimentary canal, but I counted forty-nine half-grown eggs in the ovaries. It should be understood that when adults are mentioned, females are understood unless otherwise stated.

August 22d, went over the region between Oyster creek, Newark bay and Woodruff creek, east of the Central railroad. No larvæ were found until Woodruff creek was reached, and then, in pools on both sides of that creek, they were plentiful. This breeding area can be very easily drained into Woodruff creek by short ditches. There are some ditches here, but they are partly filled and really make good breeding places for the mosquitoes.

Of the larvæ sent in, one vial contained a number of less than half-grown *sollicitans* and all the others were *nigritulus*.

August 23d, explored the region between Oyster creek, Newark bay and Sloping creek. The meadows here slope and the high tide covers a lot of ground. But it all drains clear at the ebb and there are few holes or pools. No mosquito larvæ were found on this day.

Twenty adult *sollicitans* were sent in, none of which showed developed ovaries, and only two of which showed traces of food in the gut.

August 25th, went to the piece of ground lying between Woodruff creek, Great island and the branch of the Central railroad leading to the Elizabeth race-course. Along a farmer's road, from the almshouse to Great island, are a number of pools, in which no larvæ were found except near Woodruff creek. No others were found until nearing Bound creek, where there is a small danger point, which can be easily drained into Bound creek.

The larvæ taken this day were mostly *territans* and *nigritulus;* one vial contained a brood of very recent *sollicitans* larvæ,

August 26th, worked on the south side of Woodruff creek, west of the Central railroad, to the farmer's road. Between the railroad and the road is the worst breeding place yet found. It is close to the upland and could be easily filled from the highland or drained into the creek. The ground is full of holes and ditches, but the ditches are filled only at extra high tides, and as they do not allow all the water to run off, they really make the worst sort of breeding places. Only a few of the holes and ditches had any fish.

The larvæ collected in this area by Mr. Brehme are mostly *nigritulus,* only a few *territans* being intermingled. Most of the larvæ were full-grown, or nearly so, and there were many pupæ as well.

A large series of adults was collected this day, including *sollicitans, cantans, sylvestris, nigritulus* and *territans.*

Of the *sollicitans,* fifty-one examples had no food in the alimentary canal and the ovaries were in nowise developed; four had fed on blood of some kind, yet had undeveloped ovaries; only one, showing no food remnants in the alimentary canal, had nineteen more than half-grown ova.

August 27th and 28th, covered the ground west from the farmer's road to the Catholic cemetery, finding wrigglers all along the edge of the meadow, in the pools formed there. This entire area should drain into Woodruff creek.

August 29th, completed the work along the edge of the meadow to the Pennsylvania railroad line at Waverly. Larvæ were found

along the edge of the meadow in every pool and ditch. There is a wide ditch running in from Bound creek which can be made of service in draining this area.

August 30th, examined the meadow area near the Pennsylvania railroad, between Peddie Street canal and Wheeler's creek, finding no wrigglers anywhere.

Most of the larvæ brought in from this area were *nigritulus,* with a scattering of *territans* intermixed. In all, there were twenty-two vials in the series of edge of meadow collections; in only three of these were there short-tube larvæ, less than half-grown, which were probably *sylvestris.*

Fourteen bottles of living larvæ were also brought or sent into the laboratory from the same ground, and some adults were bred out of all of them. In all cases the water was at least brackish, and in most it was decidedly salt—even to the taste—as much so as the bay itself. The water in each bottle was tested by the tongue to make this positive.

By far the greatest number of adults bred were *nigritulus; territans* coming in far behind, while a few *sollicitans,* and about as many *sylvestris,* completed the series.

Of the adults collected on the meadow on the 27th there were a few each of *sylvestris* and *cantans,* quite a number of *territans,* and thirty-nine specimens of *sollicitans.* None of the latter had the ovaries at all developed and only three of them had fed, if absence of food remnants can be relied upon.

August 28th, sixty-five examples were sent in, and of these, eighteen were *nigritulus,* one was *sylvestris* and the remainder were *sollicitans.* Of the latter, nine had more or less obvious blood clots or particles in the alimentary canal, and of these, six contained ova less than half-grown. One example, in which the food had been pretty well absorbed, had the eggs more than half-grown, while one other, in which the abdomen was distended with eggs, had no food remnants at all.

September 1st, went by boat to Sloping creek, working inland from it and from the bay shore. Larvæ were found in a few places well up on the meadow, near the creek banks. The land is rather high, and the wet area would drain easily into Sloping creek. Some work has been done here by Senator Kean, and when the improvements contemplated by him are completed this breeding area will disappear.

Two vials of larvæ were sent in, of which one contained a large number of *nigritulus* only; the other contained eleven *nigritulus,* one

territans, one *sollicitans*. The adults were, *nigritulus*, eighty-seven, of which fifty-seven were males; *sollicitans*, five, of which two were males. Of the three females, one only had partaken of some vegetable food, while in none were the ovaries at all developed.

September 2d, worked west from Oyster creek to Stoffel creek, which is really only a wide ditch. On the edge of this creek, near the mouth, I found a few pools with wrigglers, but the place is not very bad. Most of the time it is entirely dry, and, as it lies high, it can be easily drained into Stoffel creek.

Of the larvæ sent in all save two were *sollicitans*, and some of these were very small, indicating a recent extension of the pools. The odd larvæ were *territans*.

Of the adults sent in eighty-eight were *nigritulus*, and of these fifty-two were males. There were five *sollicitans*, of which two had remnants of blood food, one of the latter having the abdomen distended with ova that were more than half-grown. The interesting feature in the adult sendings from this region is the predominance of *Culex nigritulus*, which finds in the pools on the high meadows and at the borders of the upland the conditions most suited to it. As the adult of *nigritulus* very closely resembles that of *pungens*, it is more than probable that some of them may, if they get into the town, be counted in with the common species. There were also three specimens of *Anopheles maculipennis*.

September 3d, looked over the stretch along Peddie Street canal and along Dead creek, working towards the upland. A breeding area was found just at the junction of the creek and canal, which can be very completely drained into Dead creek by just cutting through the bank.

In the two vials of larvæ sent in all were *Culex nigritulus*. Among the adults there were two male and five female *sollicitans*, only one of which had fed and none that had the ovaries at all developed. *Culex nigritulus* was represented by twenty males and forty females, while *Anopheles maculipennis* turned out fifteen males and forty-three females. The occurrence of *Anopheles maculipennis* in such numbers and in both sexes points to a local breeding place. Mr. Brehme's instructions did not include search for *Anopheles* larvæ, and the habits of that genus differ sufficiently from those of *Culex* to make the former easily overlooked when the latter only was in view. The occurrence was not unexpected, however, because larvæ were found on this meadow area last year (1901) by Mr. Dickerson.

September 4th, followed the canal to Pierson's creek and beyond it to the Central railroad, and covered the territory northward to the Lehigh Valley railroad. Larvæ were found only along Pierson's creek, toward Maple island and just southeast of the railroad crossing. These areas can be drained into Pierson's creek in one case and into the Lehigh Valley railroad ditch in the other.

All the larvæ sent in were *sollicitans* and most of them were very small. Only one pupa occurred, and it could not be determined what species that represented. The collection of adults consisted, primarily, of *Culex nigritulus,* 115 males and forty females. Next came *Anopheles maculipennis,* twenty-four males and ten females; and lastly, only four *Culex sollicitans,* none of which had either fed or begun to develop ova.

September 5th, covered the ground between Bound creek, Maple creek, Newark bay and the Central railroad. In this area breeding pools are numerous and larvæ plentiful. There are a number of ditches through this place, but they are not properly placed, not deep enough and do not drain the water. The land is too high for ordinary tides, and there are no fish even in the ditches. Relief here would be by deeper ditches into Bound and Maple creeks.

Five vials of larvæ, containing about 150 specimens, were sent in, and all were *sollicitans.* They ranged in size from very small to nearly full-grown. The adults sent in were *Culex nigritulus,* ten males and thirty-one females; *Anopheles maculipennis,* six males and twenty females; *Culex sollicitans,* two females, neither of which had either food remnants or developed ova.

September 6th, on the night from the 5th to the 6th there was an extra high tide that flooded the meadows and left pools all over the covered area in every depression that could not drain off readily. It was the water-supply for which millions of eggs on the meadow had been waiting!

On that day covered the area between Maple creek, Peddie Street canal and the Central railroad. Wrigglers were found in pools along a ditch filled with "killies;" but unfortunately there was no connection between the ditch and the breeding pools.

Four vials of larvæ were received, all of them *sollicitans* and many of them not twenty-four hours old. Of the adults there were *Culex nigritulus,* eleven males and forty-eight females; *Anopheles maculipennis,* twenty-two females; *Culex sollicitans,* five females, none of which had obvious ova, while two had fed on blood.

September 8th, worked on a piece of land lying between the Passaic river, the Central railroad, Hamburg Place and the Newark and New York railroad. This was the worst place thus far discovered, and wrigglers were there in millions. The area is a piece of what I have called rotten marsh and ideal for mosquito multiplication.

Eight vials of larvæ were sent in, containing in the aggregate 630 specimens, all of them *sollicitans*. With few exceptions, these specimens were less than half-grown.

September 9th was an unfit day and brought to head another experiment begun on the 1st, when Mr. Brehme allowed one dozen *Culex sollicitans* to gorge upon his blood, capturing each individual in a separate vial and afterward turning them loose in large jars at his home. On the 8th all were dead, and on the 9th were bottled and sent to me. Three had fallen into the water dish in the prison jars and were not sent. Of the remainder, six did not show any blood remnants in the alimentary canal, and in none had the ova begun to increase in size. The other three were equally devoid of food remnants, but in two the ova were more than half-grown, and in the third the eggs were full-grown and getting into the transparent gray stage.

The experiment did not result quite as I had hoped, but showed at least that in a period of seven days a full blood-meal can be completely digested and excreted.

September 10th, continued the exploration of the area entered on the 8th, and toward the mainland it grew ever worse, the pools being simply black with larvæ. Mr. Brehme said he had never seen larvæ so abnndant before—in a dip with his little coffee-strainer, he obtained twenty to twenty-five each time—with his net he could get a pint of larvæ at a single stroke. Another point noted was that, while larvæ were very plentiful, adults were rare and not at all troublesome. A ditch, with a strong flow of water, runs within fifty feet of the worst of this area.

Ten vials of wrigglers were sent in, all of them *sollicitans*, few of them much more than half-grown and aggregating a little over 1,000 specimens.

It was at this time, when the uniform size of the larvæ from so large an area attracted attention, that I began to inquire what had happened a few days ago and learned of the heavy tide of the 5th inst.

September 11th, found conditions south of Hamburg Place not quite so bad as on the north, but yet with numerous areas of the

same general character. After determinating this point went to Pierson's creek, about a mile to the south, to see if there were larvæ in the pools filled by the tide on the 5th. There were wrigglers there, but also "killies," and very few were collected. These were separately tubed and turned out—*sollicitans,* ten, mostly small; *nigritulus,* six, mostly large.

The larvæ collected on the 11th were in fourteen vials and aggregated 1,277 specimens, of which two were separated as probable *sylvestris,* and all the others were *sollicitans.* Adults were reported as rare at this time, and the captures for the 10th and 11th numbered only fifty-three, of which six were *nigritulus.* Of *sollicitans,* there were twenty-one males and twenty-six females, and of the females, seven had the ovaries entirely undeveloped. In fifteen the eggs were less than half-grown and no food remnants could be found; in one specimen, in which the ovarian development was about the same, there was an appearance of vegetable food, and in two others, where the eggs were much less than half-grown, traces of blood were obvious. One other example had eighty-nine just countable eggs and no appearance of recent food.

September 12th, continued the exploration south of Hamburg Place to the bay and wrigglers were found in every pool. Eight vials were brought in, all *sollicitans,* but now beginning to pupate; in all, 436 specimens, of which twelve were pupæ. Adults were all *sollicitans,* forty-three males and sixteen females. Of the latter, eleven had not fed, nor had ovarian development begun; in four the eggs had begun to grow, but no food was found; in one example, in which the ova were half-grown, remnants of blood food were identified.

September 13th, Mr. Brehme collected and brought to New Brunswick some jars of living wrigglers from the Hamburg Place area. He reported that the larvæ were now full-grown and that the change to pupal form was becoming general; a statement borne out by his specimens. He added, also, that the breeding pools were becoming smaller and, unless refilled, could not last many more days.

I was not quite satisfied, after discussing the matter with Mr. Brehme, that the area first examined in August was always so free as he had fonnd it at that time; so, as there had been a high tide and two heavy rains of late, he went again over the region between Woodruff creek, Oyster creek, Newark bay and the Central railroad. The meadows were very dry, even after the heavy rain on Saturday

(13th), and very few pools were found. The first larvæ were found near Wood creek, in one of a series of pools, and this was the only one that had no fish. No more wrigglers were seen until another pool area was found, near Oyster creek. Here a pool, 7 x 3 feet, was filled with them, but they had only about three-fourths to one inch of water and mud, which would be entirely dry in twenty-four hours, long before the larvæ could possibly reach the pupal stage. Similar conditions were found in a number of other pools. The pool first found is only about twenty feet away from a tide ditch containing fish, and fish were in pools 100 feet away. Mr. Brebme's conclusion is that this place cannot become bad in an ordinarily dry season because all the larger, more permanent pools are connected by little channels with main ditches and always contain fish.

All the larvæ sent in were *sollicitans*. Of the adults there were twenty-one male and twenty-one female *Culex nigritulus;* tweve female *Anopheles maculipennis,* and a few *Culex sollicitans,* which, by accident, were not counted or examined.

September 16th, I visited the Hamburg Place area with Mr. Brehme, and found the pools fast disappearing, while pupæ rather than larvæ were the rule. On the 11th and 12th Mr. Brehme had noted the rarity of adults; on the 16th they simply swarmed and made continuous fanning necessary to keep them off. The number was constantly increasing, and males as well as females were present in great quantity. It would be difficult to estimate the number of specimens bred out of this Hamburg Place area, and I doubt whether it can be done in terms of less than eight or even nine figures.

This case, however, illustrates the occurrence of a typical swarm. The period preceding September 5th had been dry and hot, and the meadow was dry, the adult mosquitoes few in number and dying off as their eggs were laid.

The very high tide of the 5th brought in the necessary water, soaked the marsh and left many pool areas without fish, in which eggs at once hatched and larvæ were already present on the 6th. Pupation began on the 12th and 13th, and by the 16h the great bulk was in the adult condition. Until this tide came the meadow was safe, and had there been any provision for even slow drainage, it would have remained so. The occurrence of two days of heavy rain probably prolonged the life of many pools sufficiently to enable them to mature their crop of larvæ.

In the afternoon Mr. Brehme made a preliminary exploration along the north bank of the Elizabeth river, near its mouth. He found there conditions as bad or worse than those on the Hamburg Place area. The character of the meadow is the same and the stage of development was also the same. Quite evidently, the same tide that supplied Newark was equally good to Elizabeth. Mr. Brehme speaks of adults by the million, and determined at once that to the south Elizabeth had a much greater source of danger than to the east.

I wrote a brief note of this occurrence to Dr. Robinson, at Elizabeth, and predicted that the next south wind would fill the city with salt marsh mosquitoes. It was a safe prediction, and was promptly verified.

Of the few larvæ taken all save three were *sollicitans;* the three oddities proved *nigritulus*. The adults were two male and five female *nigritulus;* eleven male and nineteen female *sollicitans*. Of the latter fifteen had undeveloped ovaries and no food remnants; one had a blood clot filling, but no developing ova; two had developing ova, without obvious food remnants, and one had the eggs half-grown, with remnants of blood food in the alimentary canal.

September 17th, worked along the Passaic river, between the plank road and the Newark and New York railroad. This place is well drained and wrigglers were found in only one pool, which was fast drying up. Worked, also, along the south side of the railroad, where nothing but cat-tails grow, and went through the whole place, just to see if mosquitoes do breed in such places, bnt found not even a sign of a wriggler.

Only two *sollicitans* and two *nigritulus* larvæ were sent in, but there were about thirty pupæ and pupa shells, probably *sollicitans*. Of the adults one male and eight females were *nigritulus;* thirteen males and seventeen females were *sollicitans*. Of the female *sollicitans* nine had neither eggs nor food remnants apparent; two had blood food, but no developing ova; three had the ovaries increased in size, but were without food; two had remnants of blood food and ova two-thirds-grown; one, in which the alimentary canal was clear, had the eggs full-grown. the shell becoming gray, translucent.

September 18th, finished up the north end of the Newark meadow, north of the plank road, and found it safe and well-drained. There was only one small pool that fills at extra high tide, and this had a few wrigglers.

In the afternoon revisited the territory explored September 5th, to see if it was as bad as it was then; found that it was, and that all the

pools were full of larvæ. This is a continuous breeding area, and the meadow is comparatively low and wet.

Of the larvæ sent in—the vial from the north meadow area—one was *sollicitans* and five were *nigritulus*. The afternoon's collecting was all *sollicitans*, consisting of 112 larvæ and fifty-one pupæ. The adults were *Anopheles maculipennis*, three males; *Culex nigritulus*, two males and three females; *Culex sollicitans*, sixteen males and twenty-four females. Of the female *sollicitans* sixteen showed neither food nor developed ova; four had eggs varying from half to nearly full-grown, without food remnants; one had a blood-distended abdomen, containing no developed eggs, and three had remnants of blood food, with eggs half-grown or more.

September 19th, worked along the north side of the Elizabeth river, west of the New York and Long Branch railroad, and found two rather bad breeding areas, but not so bad as those at the mouth of the river. This area can be very easily drained into the Elizabeth river.

All the larvæ and pupæ, 217 in number, were *sollicitans*. The adults—thirteen males and nineteen females—were also *sollicitans*. Of the females twelve had neither food nor developing ova; two had developing ova, without food remnants, and five had eggs half-grown or more, with remnants of blood food.

September 20th, explored the territory lying on the south side of the Elizabeth river and east of the New York and Long Branch railroad. This is not so bad as the north side of the river, but many pools were found in which wrigglers occurred in great quantity. The whole of this area drains naturally towards the Elizabeth river.

Of the larvæ sent in thirty-two were *sollicitans* and five were *nigritulus*. Of the adults one male and two females were *nigritulus* and eleven females were *sollicitans*. The latter, to all appearances, had neither fed nor had they developed ovaries.

September 21st was Sunday, and Mr. Brehme went fishing instead of hunting; but he combined business with pleasure, and made one of the most important observations of his seasou. I give it nearly as he states it: "I was down the Bound creek yesterday, fishing for tomcod. When I went down along Maple creek at 6 A. M. I saw a pool that was filled with wrigglers. I noticed that we had one of the highest tides that I have seen since 1895, so I thought, while fishing, that it would be a good idea to make a search over the meadows and see if any 'killies' were thrown in on the highest points between Maple

and Bound creeks. After I got through fishing, when the tide had run out five hours and the fish did not bite any more, I took a look at the places. To my surprise, I found the places that were nearly dry this morning filled with water and hundreds of 'killies' in the pools. I looked closely, to find the wrigglers which I had seen only nine hours before, but did not find even one. In the one pool where I had seen so many there were at least 200 'killies.' So, draining this place just a little would certainly do away with the mosquito breeding."

September 22d, worked along the south side of the Elizabeth river, west of the New York and Long Branch railroad. It is certainly a bad spot, and quite a number of pools containing wrigglers was found. But the water was again unusually high, and the meadows were so deeply covered that progress was slow and many points could not be reached at all.

Of the larvæ sent in two vials contained *sollicitans* only; the third contained twenty-one *sollicitans* and five *nigritulus;* the fourth had twelve examples of a species very like *sollicitans,* but which I recognized as distinct. Later, I bred from this larva an adult, that was determined as *sylvestris,* and so the species will be referred to here. There was also a larva of *Anopheles maculipennis* in this fourth bottle. The adults taken were *nigritulus,* three males and two females; *sollicitans,* ten males and sixteen females. Of the female *sollicitans* eleven had not fed recently and the ovaries were undevloped; in one the ova had just begun to enlarge, though no food remnants were found, and in four there were half-grown ova and remnants of blood food.

September 23d, went along the south side of the Elizabeth river, from Arthur Kill west to the place reached on the 20th. This is another bad spot, and wrigglers were found everywhere, in every pool, even though it was very high water. During the day, though the meadow was everywhere covered by recent tide pools, very few "killies" were seen. Drainage of this area can be made to the Kill and to the river.

Three vials of larvæ sent in, and, with one exception, all were *sylvestris;* there was one *nigritulus.* Of the few adults taken three males and three females were *nigritulus;* eight females were *sollicitans.* None of the latter had the ovaries at all developed, though three had the abdomen distended by blood clots.

September 24th, worked along the west end of the Elizabeth river as far as meadow land is found. This area is not so wet as farther down, though there are many pools that seem just about right for

wrigglers. Yet there are not so many there, and the place is not near so bad as down stream. And this completes the survey of the area at the mouth of the Elizabeth river.

Three vials of larvæ were sent in, and all save three were *sylvestris*. Of the three, two were *nigritulus* and one was *sollicitans*. Of the adults, four males and two females were *nigritulus;* twelve males and thirteen females were *sollicitans*. The female *sollicitans* showed neither food remnants nor developing ovaries.

September 25th was a very rainy day, and Mr. Brehme gave it up at 1 P. M., when thoroughly soaked. The time was put in near Morse's creek, about one mile south of the Elizabeth river. There were numerous pools here filled with very small wrigglers, only two or three days old, and, while the day was not favorable for close observation, enough was seen to show that this area is ideal for mosquitoes. There are a number of large ditches through it, and into these and the creek the land could be readily drained.

Four vials of larvæ were sent in, each taken from one pool and showing quite a variety. No. 156 had *sollicitans*, twenty-nine; *territans*, three; *nigritulus*, nine; *sylvestris*, seven. No. 157 had *sylvestris*, seventeen; *nigritulus*, one; *sollicitans*, three. No. 158 had *sollicitans*, thirty-three (all small). No. 159 had *sylvestris* only. Of the adults, one was *Anopheles maculipennis*, male; there were one male and two female *Culex nigritulus;* fourteen male and twelve female *sollicitans*. Only one female *sollicitans* showed developing ova, and this was also the only specimen in which food remnants were found.

September 26th was too stormy for even Mr. Brehme to venture out, and on the 27th he covered a thertofore unexplored part of the Newark meadow, between Peddie Street canal and Bound creek, east of the Pennsylvania railroad. No breeding places were found in the accessible parts of this area; but recent high tides and heavy rainfall had flooded everything and a large portion of the meadow was covered by from four to six inches of water.

Septemher 29th, covered the territory on the west side of the New York and Long Branch railroad, on both sides of Morse's creek, down as far as Morse's Mills. The pools found during the morning all had "killies," and no wrigglers were found; but after midday, working ing in toward the highlands they were found in numbers. Working along the meadows, found wrigglers, large and small, in great numbers, and at least three kinds. At least 95 per cent. of the larvæ are

small and they are scattered everywhere and everything is covered with water. When the water gets down to its normal condition there will be wrigglers by the million, and this will be the largest brood of the season.

Seven vials were sent in, containing over 200 larvæ. Of these, four were *Anopheles maculipennis,* two were *Culex territans,* fourteen were *C. nigritulus* and all the rest were *sollicitans,* mostly small or very small.

Evidently the high water and heavy storms of the preceding week had caused the hatching of all the eggs then on the meadow. Adults of the preceding brood were yet present "by the million" and 108 examples were sent in. Of these, four were *nigritulus* and all the rest *sollicitans*; forty-nine males and fifty-five females. Of the latter, thirty had neither food remnants nor developing ovaries; eight had recently fed upon blood, and the ovaries were beginuing to develop; eight others had remnants of blood food only, and the ova were half or more developed. In seven examples, the eggs were nearly or quite full-grown, but yet white, and in three of these remnants of blood food were found.

September 30th, a large area was covered extending between Arthur Kill and the New York and Long Branch railroad, from Morse's creek to a creek not named on the map, and west of the railroad to the upland. In the entire area east of the railroad only two small breeding pools were found, and these can be easily filled from the highland right there. West of the railroad larvæ were again found at the edge of the upland.

On the return, a lot of living larvæ were collected on the area covered September 23d, and these were sent to me that I might secure adults of the *sylvestris* breeding there. Mr. Brehme notes that the larvæ were much reduced in number and that the high tides since his previous exploration had thrown at least 100 per cent. more "killies" into the pools.

Five vials of larvæ were sent in, containing 147 specimens. Of these, three were *territans,* six *nigritulus,* and all the others *sollicitans.* Of the adults all were *sollicitans;* forty-four males and thirty-nine females. Of the females, twenty-eight had neither food nor developed ova, nine had food remnants, with eggs half-grown or less, and two had the eggs fully developed, beginning to turn gray, and no trace of food remnants.

October 1st it was raining, but Mr. Brehme worked on the south

side of the unnamed creek, both east and west of the railroad. East of the railroad nothing was found, nor was any breeding place discovered on the west side until the edge of the highland was reached. This territory has been ditched at some time, and the breeding places that remain can be easily drained into these ditches or into the large creek.

Six vials of larvæ were sent in, aggregating 147 specimens. Of these, twenty were *territans*, twelve were *nigritulus*, and the remainder were *sollicitans*, many of them small and with possibly some *sylvestris* intermixed. Of the adults, fourteen males and ten females were *nigritulus;* twenty males and sixteen females were *sollicitans*. Of the latter, eleven females had not fed, to all appearance, and the ovaries were undeveloped. Five had fed, but in only one example had the eggs begun to enlarge.

October 2d, covered the territory between the Sound Shore railroad and Tremley. In the low meadows no wrigglers were found; but along the highland there were plenty of them. This area has two creeks, the Arthur Kill and several ditches to carry off the breeding pools.

Eight vials of larvæ were sent in, aggregating 204 specimens. Of these, five were *territans*, seventy-three were *sollicitans* and the remainder were *sylvestris*. Of the adults, five males and fourteen females were *nigritulus* and twenty-two, all females, were *sollicitans*. The latter were not examined as to food or ovarian development.

October 3d, finished the lower corner of the meadow about Tremley, to the Rahway river. One little breeding area was found on the Sound Shore railroad, and the usual areas along the highland. This portion of the meadow drains into the Kill or into the Rahway river.

Eight vials of larvæ were sent in, aggregating 297 specimens. Of these, one was *territans*, one was *nigritulus*, eleven were *sollicitans* and all the remainder were *sylvestris*. The *sollicitans* and *nigritulus* were taken near the Sound Shore railroad, and all the others along the highland.

October 4th, collections were made along the Elizabeth river, and a lot of living material was secured for me. Two vials of larvæ were collected in alcohol, and all of these were *sylvestris*. The living material, however, bred out *sollicitans*, *sylvestris* and *nigritulus*, the former being in the minority, with eighteen adults as against sixty-three of the others.

Besides the living material actually mentioned, Mr. Brehme sent

in other bottles from time to time. Mr. Dickerson came daily from Newark to New Brunswick, and Mr. Brehme met him at the railroad station with such material as was to be brought on. I was thus in constant communication with Mr. Brehme, and as soon as I noted any unusual form of larva in the alcoholic material could secure a lot of living specimens from the same area. Mr. Brehme also gathered in some of the natural enemies living in the same pools with the wrigglers, but as any close collecting would have consumed too much time, very little stress was placed on this point.

The survey was intended primarily to locate breeding places and to ascertain just how much of a task is really before us in our effort to clear the ground. I believe that the result is decidedly encouraging and shows that the burden will not be nearly so great as was believed. Several scientific questions were left unsettled because of the impossibility of continuing the work after October 4th, but this does not impair the practical result obtained.

One further word regarding the collections: It would have been possible, of course, to secure much greater numbers of larvæ in each case, but Mr. Brehme was instructed to merely sample characteristic pools in each breeding area, that the dominant species in each locality might be indicated; and so, in the collection of adults, only enough were taken to show what species were flying.

A very important outcome of the survey is the fact that *Anopheles maculipennis* occurs on these marshes in considerable numbers and breeds there. This is the species of which it has been definitely proved that it is a transmitter of malarial fevers, and any large establishments built on this area before it is drained would almost certainly introduce malaria in an unpleasantly epidemic form.

Elizabeth City Collections.

At my request, Mr. Otto Buchholz, living on Adams avenue, Elizabeth, collected for me at intervals of about five days, from June 20th to October 19th, samples of the mosquitoes occurring in and about his house. The objects were to ascertain—*first*, the dominant species of the year; *second*, whether the same species occurred in equal proportions indoor and out. Therefore, the specimens collected in the house were kept carefully separated from the others, and the outside collections were made near to the house itself. The following lists are instructive:

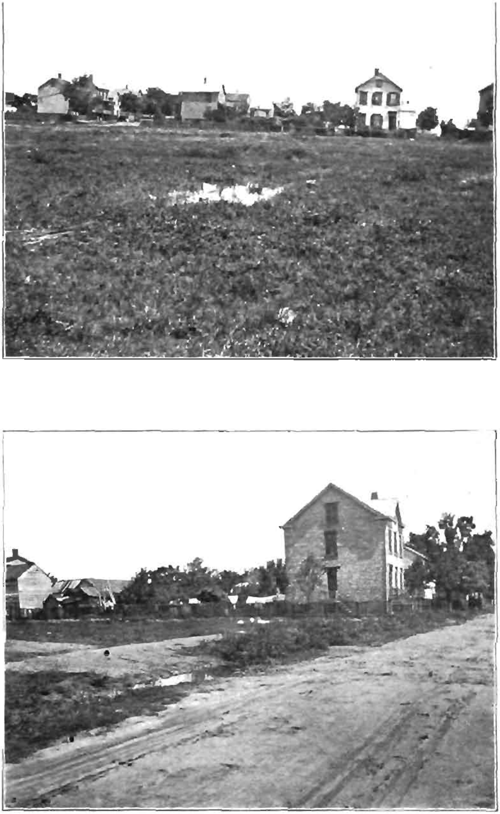


Fig. 5.

Mosquito Breeding Places in New Brunswick The upper figure shows a typical vacant-lot pool from which thousands of the insects emerge, and which could be easily filled: the lower figure shows a neglected gutter, partly overgrown and forming pools in which water remains for weeks. From original photographs.

Out-door Collections.

June 20.	Culex sollicitans, all females	40	
	" cantans, all females	4	
	" pungens 5 males, 5 females	10	
			54
" 25.	" pungens, 109 males, 2 females	111	
	" sollicitans, all females	6	
			117
" 30.	" sollicitans, all females	12	
	" pungens, 1 male, 17 females	18	
			30
July 5.	" sollicitans, all females	24	
	" pungens, 29 males, 6 females	35	
	" cantans, all females	4	
			63
" 10.	" pungens, 118 males, 18 females	136	
	" sollicitans, all females	8	
			144
" 15.	" pungens, 16 males, 8 females	24	
	" sollicitans, all females	5	
			29
" 20.	" pungens, 22 males, 27 females	49	
	" sollicitans, all females	4	
			53
" 25.	" sollicitans, all females	4	
	" pungens, 3 males, 14 females	17	
			21
Aug. 5.	" sollicitans all females	20	
	" sylvestris, all females	11	
	" pungens, all females	2	
			33
" 10.	" sollicitans, all females	19	
	" sylvestris, all females	5	
	" pungens, all females	4	
			28
" 15.	" sollicitans, all females	26	
	" sylvestris, all females	16	
	" pungens, all females	3	
	Anopheles punctipennis, females	2	
			47
" 20.	Culex sollicitans, all females	12	
	" sylves ris, 2 males, 12 females	14	
	" pungens, all females	4	
	Psorophora ciliata, female	1	
			31
" 25.	Culex sollicitans, all females	16	
	" sylvestris, 9 males, 46 females	55	
	" pungens, all females	6	
	" territans, female	1	
			78

Aug	30.	Culex sollicitans, 1 male, 7 females	8	
		" sylvestris, all females	7	
		" pungens, 6 males, 29 females	35	
		Anopheles punctipennis, female	1	
				51
Sept	1.	Culex sollicitans, all females	6	
		" cantans, 7 males, 16 females	23	
		" sylvestris, 3 males, 2 females	5	
				34
"	5.	" cantans, all females	2	
		" pungens, 9 males, 1 female	10	
				12
"	10.	" pungens, 12 males, 5 females		17
"	15.	" sollicitans, all females	3	
		" cantans, all males	2	
		" pungens, all males	5	
				10
"	20.	" sollicitans, 2 males, 20 females	22	
		" sylvestris, 1 male, 4 females	5	
		" pungens, 15 males, 26 females	41	
		Anopheles punctipennis, female	1	
				69
"	25.	Culex sollicitans, 1 male, 7 females	8	
		" pungens, 5 males, 9 females	14	
		Anopheles punctipennis, female	1	
				23
"	30.	Culex sollicitans, 1 male, 2 females	3	
		" pungens, 5 males, 15 females	20	
		" cantans, 1 male, 2 females	3	
				26
Oct.	5.	" pungens, 2 males, 16 females	18	
		" sylvestris, female	1	
				19
"	19.	" pungens, 1 male, 34 females	35	
		" cantans, 1 male, 4 females	5	
				40
		Altogether		1,029

These specimens are divided, as to species and sexes, as follows:

Culex sollicitans,	males, 5;	females, 241	246
" cantans,	" 11;	" 32	43
" sylvestris,	" 15;	" 104	119
" pungens,	" 363;	" 251	614
" territans,		" 1	1
Anopheles punctipennis,		" 5	5
Psorophora ciliata,		" 1	1
			1,029

This shows strikingly that *pungens* is a local species, more than half of the specimens being males, while *sollicitans* is an intruder, only five males out of 246 specimens being taken during the season. *Cantans* and *sylvestris* breed closer by, and probably within the city limits.

From the large number of male *pungens* taken, it is probable that there is a local breeding point for that species close to where the collections were made, and that the species is unduly represented for that reason. It is also possible that some of the specimens called *pungens* are really *territans:* indeed, it is almost certain that such is the case, but the material examined was in alcohol and discrimination is not easy.

The list of indoor captures is as follows:

June 20.	Culex cantans	2	females.	
	" pungens	3	"	
	" sollicitans	2	"	
		—		7
" 25.	" pungens	5	"	
	" sollicitans	2	"	
		—		7
" 30.	" pungens	6	"	
	" sollicitans	1	"	
		—		7
July 5.	" pungens	5	"	
	" sollicitans	3	"	
		—		8
" 10.	" pungens	26	"	
	" sollicitans	1	"	
		—		27
" 15.	" pungens	17	"	17
" 20.	" pungens	11	"	11
" 25.	" pungens	13	"	13
" 30.	" pungens	20	"	
	" sollicitans	1	"	
		—		21
Aug. 5.	" pungens	22	"	22
" 10.	" pungens	14	"	14
" 15.	" pungens	22	"	22
" 20.	" pungens	18	"	18
" 25.	" pungens	16	"	
	Psorophora ciliata	1	"	
		—		17
" 30.	Culex pungens	17	"	
	" sylvestris	1	"	
		—		18

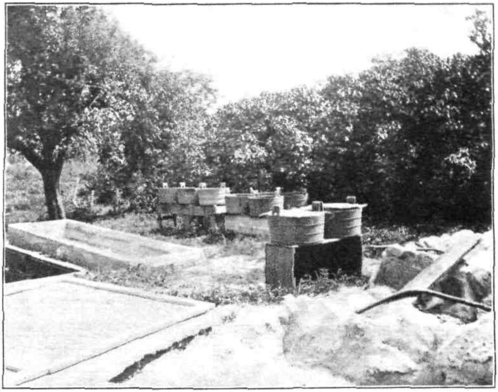
Sept. 5.	Culex pungens	6	females.	6
" 10.	" pungens	16	"	16
" 15.	" pungens	5	"	
	Anopheles maculipennis	1	"	
		—		6
" 20.	Culex pungens	10	"	
	" territans	6	"	
	Anopheles maculipennis	1	"	
		—		17
" 25.	Culex pungens	6	"	
	" sollicitans	2	"	
		—		8
" 30.	" pungens	10	"	
	" territans	7	"	
		—		17
Oct. 5.	" pungens	5	"	5
" 10.	" pungens ... 1 male,	3	"	
	Anopheles maculipennis	1	"	
		—		5
" 19.	Culex pungens ... 1 male,	8	"	9
	Altogether			318

Divided as to species, we get—

Culex pungens	286
" sollicitans	12
" cantans	2
" sylvestris	1
" territans	13
Anopheles maculipennis	3
Psorophora ciliata	1
Total	318

In other words, while outdoors the females of *pungens* and *sollicitans* were in almost equal numbers, only twelve *sollicitans* out of a total of over 300 were found indoors.

In all, 1,347 specimens were examined, and the justice of the title "house mosquito" for *pungens* is fully demonstrated. It is absolutely necessary, to secure indoor comfort, that the local breeding places of this species must be destroyed or treated. It is absolutely necessary, to secure outdoor comfort, that the salt marsh species be dealt with. As to the local breeding places in Elizabeth, the report made by Dr. Wm. F. Robinson to the organization that conducted the mosquito campaign in that city gives useful information. The sewer catch-basin as a mosquito breeder is very prominently brought out in that report, and this point is of great importance to any similar organization that may be hereafter formed to deal with local conditions.



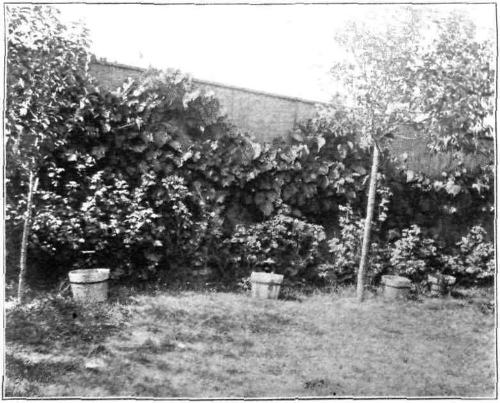


Fig. 6.

Upper figure represents the Experiment Tubs at Delair; the lower, the Breeding Pails at New *Brunswick. From original photographs.*

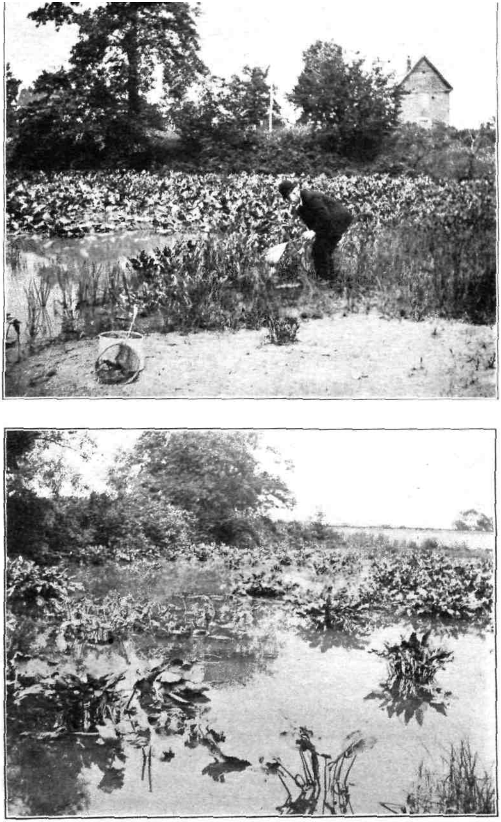


Fig. 7.

Breeding Places for Anopheles. In the upper figure Mr. Seal is standing in the shallow grassy margin where larvæ are numerous; the lower figure shows more open water, where fish can get freely and where few larvæ occur. From original photographs.

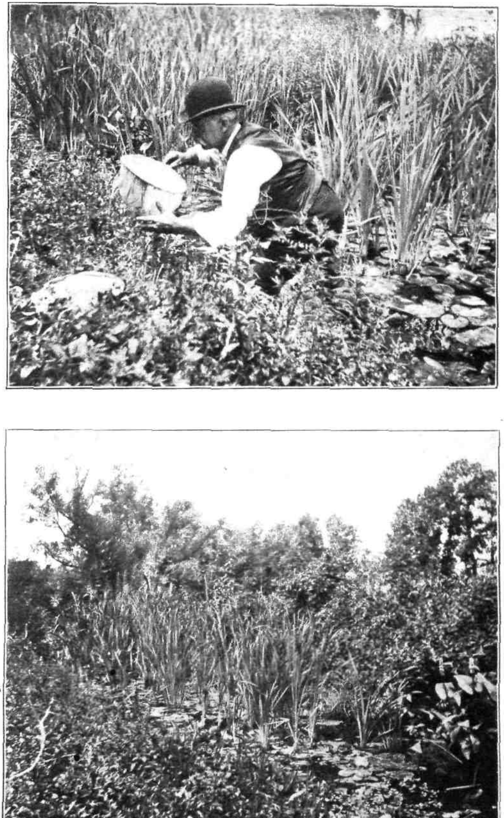


Fig. 8.

Open swamp area making excellent places for Anopheles breeding. The upper figure shows Mr. Seal among the rushes and lily pads collecting larvæ. From original photographs.

This particular sort of breeding place is easily dealt with by the municipalities where it occurs, and the process may include either actual disinfection or a mere oiling to stop breeding.

Drainage.

It has appeared again and again in this report that drainage, or ditching, is the method by which bad breeding areas are to be redeemed and made harmless. The matter of cost will always be an important consideration in all work to be undertaken; hence, when I learned that at Newburyport, Massachusetts, there was a practical machine for cutting drainage ditches in salt marshes, I went to that city September 2d, and saw Mr. Mark B. True, the inventor. Plate 9 gives a fair representation of the hand-power machine, as it now stands on the Salisbury marshes. This machine has been in service over twenty years and does good work yet; a much larger power machine was also seen, but in such position that it could not be photographed. This machine cuts ditches four to eight inches wide, two to three feet deep, at the rate of about forty to 100 rods per day, with a crew of four men, of whom two work the wheel and two move the tracks upon which the machine runs. Improvements recently made have improved its efficiency to such an extent that the persons owning the patents offer to take contracts for ditching at ten cents per rod. At this rate, areas like those about Newark and Elizabeth could be thoroughly drained for a few hundred dollars and the work would be done for good. Even such marsh areas as those at the mouth of the Mullica river lose their terrors, while such strips as those on the bay-side of the Barnegat island can be thoroughly freed of breeding places at a sum that would be made up by the increased hotel patronage in one season. This subject is scarcely ripe for final treatment at present, but the possibility of effective cheap ditching in necessary areas only, will bring the whole problem down to a simple business proposition. There is no question of the possibility of accomplishing the end—the only question is one of cost.

It is unfortunate, perhaps, that the owners of the True ditcher refuse to sell machines; they prefer to secure contracts to do the work, and, of course, will scarcely care to undertake to drain an area which is not large enough to make it pay to bring their machines down.

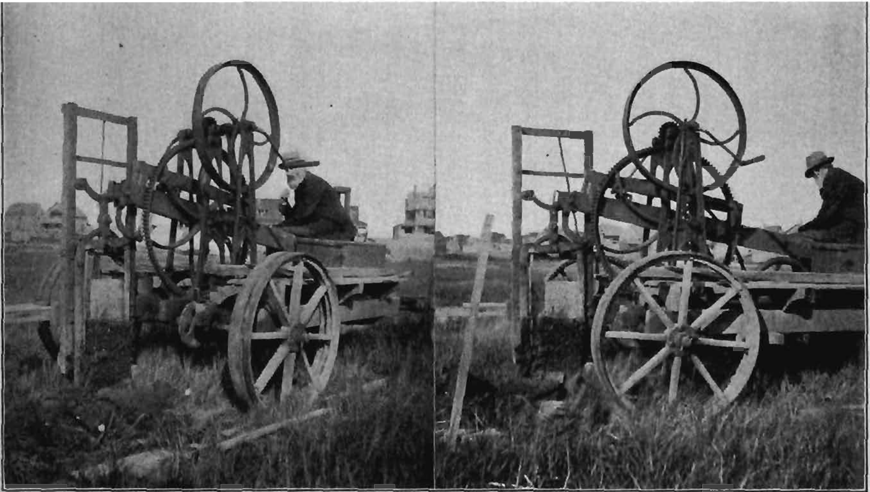


Fig. 9.
The True Ditcher from two points of view, showing a sod partly lifted out. From an original photograph.

APPENDIX A.

A STUDY OF CERTAIN MOSQUITOES IN NEW JERSEY,* AND A STATEMENT OF THE "MOSQUITO-MALARIA-THEORY."

HERBERT PARLIN JOHNSON, PH.D.

Introduction.

The following studies were undertaken as a part of the investigations conducted during the summer of 1902 by Dr. John B. Smith, with the object of devising ways and means of abating the mosquito nuisance and malaria in New Jersey. My subject was the relation between the prevalence of malaria and abundance of mosquitoes of the genus *Anopheles*, and the particular problem in hand was to determine whether *Anopheles punctipennis* is a carrier of malaria. The gathering of data regarding the breeding habits, distribution, etc., of our common mosquitoes also came within the scope of the season's work.

Of the three species of *Anopheles* found in New Jersey, only *Anopheles maculipennis* is positively known to be a carrier of malaria. *A. crucians* is practically ruled out on account of its extreme rarity. It remains, therefore, to ascertain what is the status of *A. punctipennis* in the malaria problem. This is much the commonest species of the genus in New Jersey, and in some localities is almost the only *Anopheles*. As it is found practically everywhere in the Eastern United States, it is a matter of hygienic, as well as of scientific, moment to find out whether it is capable of transmitting malaria. The only road to exact knowledge is experiment, and this is sure to be a path beset with difficulties. In fact, it is only by a concurrence of fortunate circumstances that such an experiment can succeed. Usually several

* Dr. Johnson's statements and conclusions concerning mosquitoes are his own, and the conclusions are not necessarily identical with my own in all particulars.

attempts must be made before every condition is fulfilled. It is not surprising, therefore, that for the past season there is only a record of failure. The summer was exceptionally healthy, even in localities usually malarial. Very few cases of malaria were reported by the physicians who are co-operating in the experiment. Owing to continued unsuccess in New Jersey, in the early part of September I requested Dr. Wm. N. Berkeley to attempt it in New York with mosquitoes of my rearing, and he kindly consented. Although he had access to patients at the Bellevue and Presbyterian Hospitals, even there no opportunity offered. Never before had there been so few cases of malaria. Thus the experiment was completely balked.

It is a pleasure to express my sincere thanks to the Harrison Board of Health for the use of one of their rooms as a laboratory; to Mr. John McClure, the house inspector of Harrison, for many favors; to Mr. Horatio N. Parker, the health officer of Montclair, for much friendly assistance; to Dr. R. N. Connolly, bacteriologist to the Newark Board of Health, for many laboratory favors; to Dr. William N. Berkeley, of New York, for generously assisting with the experiment, and to the many physicians of Newark, East Newark, Harrison, Kearny, Montclair and Verona, who took a friendly interest in the investigation.

The Species Met With.

No effort was made to form a comprehensive collection of mosquitoes or to determine how many species inhabit the limited region examined. The species which concern the public are obviously those which are abundant enough to be a menace to health or a source of discomfort. There were encountered but four of this description—*Culex pungens,* the common house mosquito, breeding in a greater variety of localities than any other species; *Culex sollicitans,* the ring-legged or salt marsh mosquito, an almost intolerable pest in and about the meadows, also on verandas and front porches after sundown; *Anopheles punctipennis,* fairly abundant during the latter part of the season, but only seen by me in the free condition as larvæ or pupæ; finally, *Anopheles maculipennis,* not abundant, but of great interest because the only one of our species positively known to be a carrier of malaria.

Mere mention is made of three other species—*Culex territans,* similar to *C. pungens,* but less common and local; *Uranotænia sapphirina,*

a small, rare and very pretty species, twice met with; *Anopheles crucians*, a rare form closely resembling *A. maculipennis*, of which one specimen was reared from the pupa.

As of most interest in the present investigation, study was concentrated on the two species of *Anopheles*, especially upon *A. punctipennis*, some hundreds of which were obtained in the larval state, and scores were reared to adults. *Culex pungens* was also studied, but this was incidental. The species has received a good deal of attention at the hands of American Entomologists, and its near relative in Europe (*C. pipiens*) has also been carefully investigated by Kerschbaumer and others. Most of our knowledge of the life history of the genus *Culex* is based upon these two species. The reasons are obvious—they are both abundant and both are easily reared in confinement. Since the eggs are laid in good-sized bunches, known as "egg-boats," which float on the surface of the water, they are easy to find, and one can start from the egg in rearing experiments.

Of the four recognized and well-established species of *Anopheles* inhabiting the United States, the only one positively known to be a transmitter of malaria is *Anopheles maculipennis* (*A. quadrimaculata*, of many American writers; *A. claviger*, of German and Italian authors). Howard makes the interesting conjecture (1901,* p. 93) that "it is quite within the bounds of possibility that malaria was originally an European disease, and that not only was the disease itself carried from there on sailing vessels, but the mosquitoes which propogate it as well, at least to America."

Since our *Anopheles maculipennis* has been experimentally proven to be capable of serving as the transmitting host of the malarial organism (Berkeley, 1902), it might seem a foregone conclusion that the other species of *Anopheles* are also susceptible. An acquaintance with the life histories of animal parasites, particularly those of the class to which the malarial organism belongs, shows that such reasoning is apt to be fallacious. While highly probable, it is not certain; therefore, each species must be put to the experimental test.

It is a matter of importance from the sanitary standpoint to work out fully and in detail the distribution of *Anopheles* and ascertain to what extent its abundance is correlated with the prevalence of malaria. Judging from the inadequate data available, it would seem

* The year of publication is used as a reference number to the literature-list at the end of the report.

that our two commoner species often replace each other—*punctipennis* being common where *maculipennis* is rare, and *vice versa*. In New Jersey, *punctipennis* is the common species, while *maculipennis* is scarce. In New York City, as I am informed by Dr. Berkeley, *maculipennis* is the prevailing species. During the summer of 1901, Jordan (1902, p. 21) found, at Shelburne, New Hampshire, both *punctipennis* and *maculipennis*, but the latter decidely in the minority. "Only three individuals of *A. maculipennis* were raised from larvæ and pupæ captured during the season, as against thirty individuals of *A. punctipennis* from the same pools." My own experience in collecting adult mosquitoes at the Boston Parental School, West Roxbury, Massachusetts, during October and November, 1901 (Johnson, 1902, p. 213), was that *maculipennis* outnumbered *punctipennis* about ten to one.* It is interesting to note that at Forest Hills, only five miles from the Parental School, *punctipennis* is the prevailing species, while *maculipennis* is comparatively rare. (Theobald Smith, 1901.)

It is, of course, entirely possible that the relative abundance of the two species changes in the same locality from year to year. But neither seasonal nor local preponderance of one species or the other can have much significance until we know whether one species or both are carriers of malaria.

Meteorological Conditions.

Work began July 7th and closed September 17th. During this time the weather exhibited the usual variety of an eastern summer, but without a long "hot spell" and without a drought. The latter half of June had been unusually cool; this probably gave mosquito breeding a setback. Unfortunately, the temperature record is very incomplete. Daily observations were made only during a part of the season, from July 29th to September 16th. The air temperature of the laboratory was taken, also the water temperature in the aquaria. The highest temperature recorded was 30° C. (86° F.), and this but twice—August 4th and 6th. Temperatures between 26° C. (78° F.) and 30° C. were observed on nine days only—July 29th, August 5th, 6th, 8th, 9th, 11th, 18th, 26th, 27th and September 2d. A day temperature of 20° C. (68° F.) or lower was observed at no time during

***In this case only females were counted, and, by actual count, the number of *A. maculipennis* captured was 248, of *A. punctipennis*, 25.**

August and not until September 5th and 6th. When the dishes were in direct sunlight for some time the water temperature was as high as or a degree or two higher than the air temperature; otherwise, a degree or two lower (centigrade).

Breeding Conditions and Localities.

Of the conditions that favor the breeding of mosquitoes, especially *Anopheles,* most important is the aquatic vegetation usually so abundant about the edges of ponds and streams. No matter how large and deep the pond or how swift the stream, such a body of water is dangerous if it has low, weedy banks. No larvæ can live even in a comparatively slow current or in any pond with clean margins and large enough for the wind to raise wavelets, but if vegetation causes "dead water" in a stream or pond the larvæ are protected from wind, waves, currents and often from small fishes that prey upon them. Furthermore, the little bays and segregated pools of all ponds and streams with marshy banks are likely to be prolific breeding places. The particular kind of vegatation seems to make little difference, so long as it does not cut off all sunlight. Vegetation almost or even entirely submerged, like the common water-weed (*Elodia canadensis*), or with floating or slightly-emersed foliage, like pond-lilies and water-cress, or almost wholly above water, like grasses and sedges of moderate height, are alike favorable.

The season's field work has amply borne out these general statements. The banks of the east branch of the Rahway river at Maplewood and at South Orange, where it is a tolerably swift stream, are weedy in places and have little bays and lagoons. All these places harbor larvæ, especially those of *Anopheles.* In Branch Brook park, Newark, no larvæ were found in the large ponds, which have clean, well-kept shores, are free from vegetation and are exposed to the full sweep of the wind; but in the lily ponds, where not only "lilies" (*Nympheaceæ*), but arrow-leaf (*Sagittaria*) and grasses abound, there were numerous larvæ, notwithstanding these ponds are stocked with gold-fish. The grassy borders of the Morris canal are another prolific breeding place. It is well known that this canal extends for many miles through Northern New Jersey. Since it is now fallen into disuse, its banks have grown up to weeds and water plants; thus, it has become a menace to the health of the communities through which it passes.

The rather numerous bodies of standing water in Harrison have not yielded many larvæ, except in very restricted localities. This is due to (1) natural enemies, (2) lemna, (3) tall reeds and cat-tails and (4) the clean margins of most of the ponds.

The extensive flooded area between Fourth street and the Passaic river, bounded north and south by two branches of the Pennsylvania railroad, is stocked with small fishes, abounds with water bugs (especially *Notonecta*) and is partially covered with lemna or duck-weed. No larvæ were obtained here. Similar conditions obtain in the flooded meadow between Manor avenue and the Gilbert estate, with the addition of cat-tails and reeds all about the flooded area. In the great meadows to the east and south of Harrison the very dense growth of cat-tails (*Typha augustifolia*) and "reed grass" (*Phragmites communis*), both overtopping a man's head, prevents access of sunshine to the surface water, so it remains cold during the hottest weather. These vast tracts along the lower course of the Hackensack and Passaic rivers are, therefore, not everywhere productive of vast swarms of mosquitoes, as they are popularly supposed to be. It is only in certain localities where the sun has access that they afford prolific breeding places. Such localities are to be found here and there around their borders and in areas where the tall growth has been cut.

In the eastern part of Harrison are several small "kettle hole" ponds and one pond of several acres in extent known as Fairy lake. With the exception of a shallow, temporary pool, densely overgrown with button bushes and very muddy, none of these ponds are favorable breeding places, and in some of them not a single larva was obtained. As to Fairy lake, it seemed to support no animal life whatever. I was informed that so much acid had been discharged into the lake by a neighboring brass work factory as to kill all the fishes. The pond has remarkably clean, gravelly shores and contains little or no vegetation, with the exception of a few spatterdocks (*Nuphar advena*) at one end. Some of the water was brought to the laboratory and *Culex* larvæ placed in it. They lived in it indefinitely; and I am therefore inclined to think that the clean margins and unobstructed surface of the pond have more to do with keeping it free from larvæ than the acid. There are two or three very similar but smaller and uncontaminated ponds in the immediate vicinity, occupying depressions in the glacial drift like the well-known "kettle holes" of Cape Cod and Long Island. These ponds have clean margins, no vegetation, except the

spatterdocks (present in only one), are stocked with small fishes and remain destitute of mosquito larvæ throughout the season.

Conditions most favorable for the breeding of *Culex pungens* are afforded by uncovered cisterns, rain-water barrels and barnyard pools. Such are, fortunately, not numerous in Harrison and Kearny; but two of the sewers discharging to the eastward, into open ditches in the meadows, afford ideal conditions for the breeding of this species. Not that the larvæ occur in the sewer itself or in the ditches—the current is too rapid. Exceptionally high tides back flow the sewage and cause it to overflow the banks of the ditches, where they are too low, and the standing water thus created swarms with the larvæ of *Culex pungens.*

Anopheles was found breeding in abundance in only one place—the ditch in the railway cut of the Erie road, North Arlington. A fine spring furnishes much of the water, the rest of which trickles from the rocky walls. The ditch lacks sufficient fall to carry off the water, and for a long stretch it is chocked with grasses, watercress and *Cyanophyceæ* or blue-green algæ. This latter vegetation evolves so much oxygen it is floated at the surface by the bubbles, and thus furnishes both food and shelter for the surface-dwelling larvæ. These conditions—stagnant ground water, warmed by the sun, abounding in minute algæ and larger vegetation and free of fishes and most insect enemies—are perfect for the breeding of *Anopheles,* which does not appear to thrive in the foul water so favorable for *Culex pungens.* As a matter of fact, *Anopheles* larvæ may occur in waters habitable for any kind of mosquito larvæ; but, so far as the experience of the past season has shown, they are plentiful only in places where such conditions as those above described are fulfilled.

Other breeding localities for *Anopheles* were: (1) Small muck-holes near Manor avenue, Harrison (these dried up about August 1st); (2) flooded grounds on both sides of Manor avenue; (3) pool near Schuyler avenue, Arlington (only in September); (4) weedy margins of Verona lake, also its inlet and outlet; (5) ditch in eastern part of Verona; (6) tributary of east branch of Rahway river at Maplewood.

Natural Checks to the Breeding of Mosquitoes.

These are of two sorts—animal and vegetal. Among the latter is lemna or duckweed. While most forms of aquatic vegetation promote the breeding of mosquitoes, the *Lemnaceæ,* or duckweeds, are unfavor-

able, and in many waters almost or even wholly prevent it. These tiny plants consist merely of a floating frond, resembling a miniature lily pad. It is circular or more frequently lobated and three to six millimeters in diameter. From the under surface hang one or more roots, which never fasten in the soil, but derive their nourishment from the water. Its reproduction, mainly by division of the frond, is so rapid that in a short time (usually before July 1st) it completely mantles quiet waters, notably sheltered ponds and ditches, without perceptible flow. Its extraordinary abundance, often covering whole acres of shallow water, makes it an efficient protection from mosquito breeding. Wherever this plant forms a complete covering no larvæ have been found. Such places should never be treated with oil, for nature has provided a far more lasting and equally effective protection. It is probably impossible for a mosquito to lay her eggs on lemna-covered water. Even should larvæ wander in from adjacent waters, they would be unable to reach the surface for air, and would thus soon become asphyxiated. Larvæ of *Culex pungens*, injected by means of a pipette beneath the lemna in the jar shown in Figure 10, died in less than an hour. Where the lemna mantle is not complete, but presents interspaces of open water, larvæ of both *Culex and Anopheles* will usually be found in small numbers only, for lemna waters are apt to harbor the various predaceous water bugs in great numbers.

Insect Enemies.—Probably all the predatory water bugs and beetles, both in the adult and larval state, prey on mosquito larvæ. These carnivorous insects abound in shallow, permanent bodies of water wherever there is vegetation. It is not surprising, therefore, that such waters should produce far fewer mosquitoes than temporary pools where enemies are absent. Among these predatory insects the water boatmen (*Corisa* and *Notonecta*), the water striders or "skate bugs" (*Hydrobatidæ*) and the water scorpions (*Nepidæ, Belostomatidæ*) deserve mention. My observations were mainly confined to the "water tiger" or larva of the large water bettle (*Dytiscus*). The ability of this voracious creature to clear a pool of larvæ was demonstrated in the laboratory by several captive water tigers, all of them young ones, about a centimeter in length, which created havoc in some of the jars containing *Culex* larvæ.

An outdoor demonstration was afforded by a small pool about half a mile south of the North Arlington railway station, between Schuyler avenue and the meadows. To all appearances this pool, which was barely ten feet across in July and gradually diminished during the

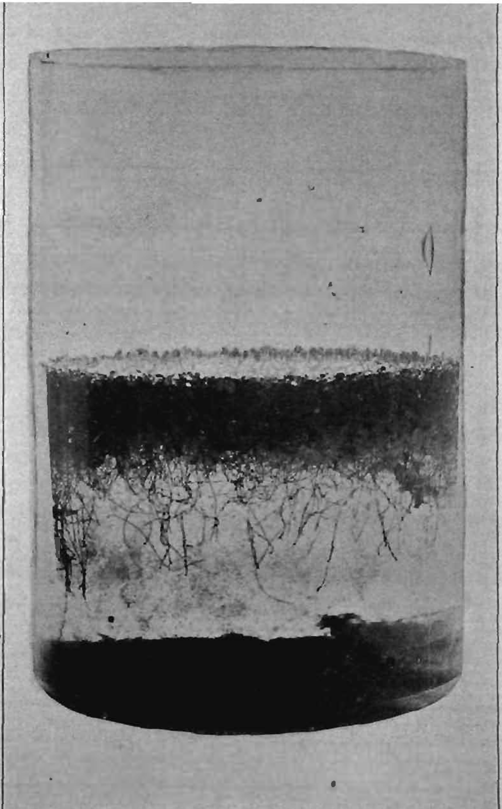


Fig. 10.

A jar of water covered with Duck Weed, showing how the roots extend into the water and bar all access to the surface. From an original photograph.

summer, possessed every condition for the breeding of mosquitoes in great numbers. It contained no fish and few water insects, with the exception of the *Dytiscus* larvæ, which seemed quite abundant. On July 26th, when first visited, the pool was thoroughly examined, but yielded very few larvæ of *Culex* and only two or three of *Anopheles*. The pool was visited again early in August, but no larvæ were found; again August 18th, when a very few *Culex* larvæ were obtained. In order to determine whether the water was incapable of supporting larvæ, ten large and medium-sized *Anopheles* larvæ were placed in a sample of it brought to the laboratory. The next morning there were only eight. The loss of two was accounted for by the presence of a very small water tiger, which had been accidentally left in the jar, and at the moment of discovery had a larva in his jaws. After removal of the enemy, seven of the larvæ completed their development, and all had pupated by the 25th, thus proving that the water was by no means unsuitable for the development of *Anopheles*. The pool was visited again September 6th. Both *Culex* and *Anopheles* larvæ were found in fair abundance, but no *Dytiscus* larvæ were seen. The absence of the voracious water tigers, owing, presumably, to metamorphosis, seems the most plausible explanation of the great increase in the number of mosquitoe larvæ.

Breeding Habits and Development.

I shall confine this division of the subject to a few personal observations. What I have learned this summer is almost entirely limited to *Culex pungens* and *Anopheles punctipennis*. The data have been gathered during only about two months (July 15th to September 15th), and are, consequently, almost wholly in the laboratory, fragmentary and incomplete.

Egg-laying.—Many observers have had, apparently, no difficulty in getting mosquitoes to lay in confinement, but such has not been my experience. In no single instance have they done so, although liberally supplied with water and given every opportunity. Hence, I have no observations to record concerning the laying or the eggs of *Anopheles*, which are hardly to be found in the breeding pools, as they do not cohere to form an egg-boat, but scatter singly over the surface, and thus generally escape detection.

The number of eggs deposited by *Culex pungens* on a limited quantity of water during a season is roughly arrived at by removing the

egg-boats every morning (they are laid only at night or in the early morning), and keeping a record of them. About July 10th an ordinary, wooden waterbucket was placed in a basement window of the Harrison Board of Health office, where mosquitoes had easy access to it through a grating. It was examined every day for a week or so, but no eggs were found; the most probable explanation being that the bucket was new and the water too clean to tempt *Culex* to lay. On August 2d, after an absence of a week on account of illness, and subsequent remissuess in examining the water, I found a brood of *Culex pungens* larvæ, about three-quarters-grown, also an egg-boat. The larvæ were all about the same size, and evidently came from a single laying. Some of them were allowed to remain and pupate. The pupæ were all removed August 7th and hatched August 9th.

Eggs were taken at the following dates:

Aug. 2	1 egg-boat.
" 4	5 "
" 5	2 "
" 6	1 "

An iridescent scum appeared on water, and no more eggs were laid until water was changed.

Aug. 14	5 egg-boats.	Bucket placed in yard.
" 15	3 "	

Bucket accidentally upset and water renewed.

Aug. 22	1 egg-boat.
" 31	1 "
Sept. 7	1 "
" 12	1 "
Total	21 egg-boats.

Adding one laying from which the well-grown brood of August 2d had hatched, gives a total of twenty-two. The nights after September 12th were cold, and no further laying had occurred up to September 17th, when observation ceased.

The weather affects egg-laying. The careful observations of Kerschbaumer (1901, p. 86) are very conclusive on this point. On cold, windy nights few mosquitoes lay their eggs; nor do they lay on rainy nights. Although the record was much interrupted by twice renewing the water, the number of eggs laid on this small quantity of water

between July 15th and September 12th, at the very conservative estimate of 150 eggs per laying, amounts to 3,300 eggs. The chances are that the great majority would have developed to the perfect insect, for food was abundant and enemies none. If 3,000 developed to the perfect insect, then about half, or 1,500, would have been females. These figures are respectfully submitted to the consideration of those who have standing water on their premises.

So far as my observation goes, the eggs of *Culex pungens* almost invariably hatch the night or early morning following that on which they were laid. Howard (1900, p. 23) mentions sixteen hours as the minimum time from egg-laying to hatching. I have noted only one exception to the usual period under ordinary conditions of temperature, and then the eggs hatched on the second morning. It is only necessary, however, to reduce the temperature to delay hatching. A bunch of eggs, found the morning of September 7th, was placed in an ice-chest at 9° C. (48° F.) at 12:30 P. M. the same day, and left there until 4 P. M. the next day. Then they were kept at room temperature, which varied from 20° to 25° C. (68° to 77° F.). They hatched on the morning of September 10th, about seventy-two hours after the time of laying.

Larvæ of Culex pungens.—The newly-hatched larvæ are about one millimeter in length, very transparent, active and have disproportionately large heads. The heart beat is plainly visible. I have timed it when the temperature was 27° C. (84.5° F.) and found it to vary even in the same larva, but to average ninety-four beats per minute.* The observation was made in the region of the thorax.

Kerschbaumer (1901) distinguishes four stages of larval growth: (1) Young larvæ, in which the thorax is still no larger than the head; (2) small larvæ, with thorax somewhat larger than the head; (3) half-grown larvæ, and (4) full-grown larvæ. A molt intervenes between each of these stages. The molt is fragmentary and inconspicuous; no larval "skins" are found in the water until the final molt, when the pupa emerges. At this time the larval skin splits open on the dorsal side of the thorax, and the two breathing tubes of the pupa are thrust out first. At this time the caudal breathing tube of the larva is still apparently in use. With a flop the pupa fairly "jumps out of its skin," and the latter floats away, the breathing tube still adhering to the surface of the water.

*Average of five counts.

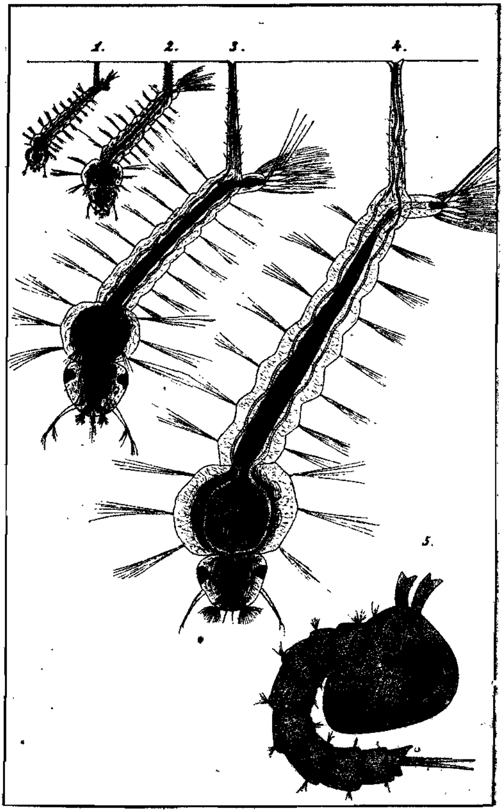


Fig. 11.

Larvæ of *Culex pipiens:* 1, young larva; 2, small larva: 3, half-grown larva; 4, full-grown larva; 5, pupa: all much enlarged. After Kerschbaumer.

Larvæ of Anopheles punctipennis.—The remarks on *A. punctipennis* under this head will no doubt hold good for *A. maculipennis*. It is doubtful whether these two species can be distinguished in the larval and pupal state. The pigmentation on the dorsal surface of the head has been adduced by both Howard (1900, Figure 17, p. 41) and Jordan (1902) as a means of differentiation; but I find it to be exceedingly variable in *A. punctipennis*, like all the coloring of these larvæ, and it only occasionally conforms to the figures published by Howard and Jordan, which, in fact, do not at all agree.

The larvæ of *Anopheles* exhibit the same four stages as those of *Culex*. A molt intervenes between every two. According to Kerschbaumer, the larvæ go to the bottom to molt. I have often observed advanced larvæ lying inert on the bottom, as if dead. They are not then readily stirred into activity. They also go to the bottom to feed, when they have reached an advanced stage of development, as I have observed many times, and as Howard (1901) has already recorded.

The coloration of the larvæ is extremely varied, and is protective. It is often hard to believe this, especially in case of the white and brown, or even white and black ones, which seem so conspicuous; but when the larvæ are amongst the aquatic vegetation, where they naturally live, they are by no means conspicuous. Their colors harmonize with their surroundings. Green larvæ are very common; and in a rich growth of blue-green algæ (*Cyanophyceæ*) I have found blue-green larvæ. Usually the tint is grass-green or brown. Whatever the coloration of the larva, it is transmitted unchanged to the pupa.

Were it not for the fact that *Anopheles* larvæ frequent places abounding with aquatic vegetation, its habitat at the surface of the water would put it at the mercy of every slightest breeze. Ordinarily, it occupies the little spaces between the leaves or stems of the vegetation. When a number are placed in a dish, without such vegetation, it is their habit to fasten to the glass at the water's edge by their caudal bristles, and they often form a row as evenly spaced as a rank of soldiers. No particular side of the dish is preferred; in fact, if there are enough, they may extend all the way round.

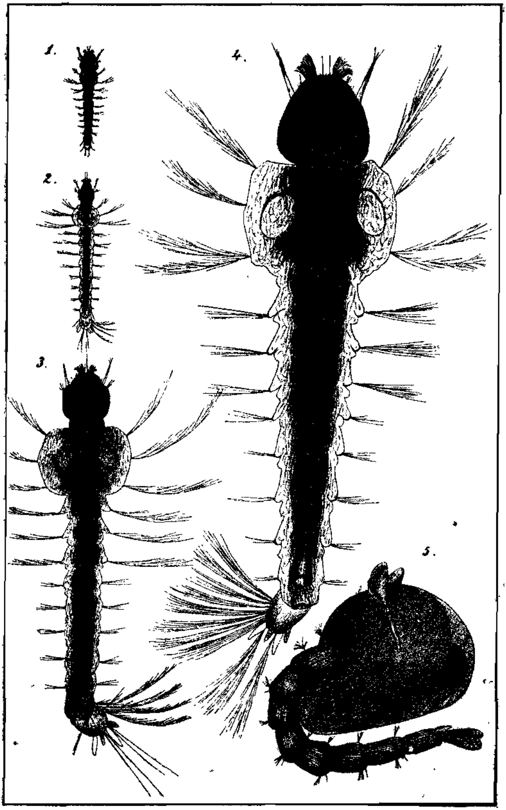


Fig. 12.

Larvæ of *Anopheles maculipennis*: 1, young larva; 2, small larva; 3, half-grown larva; 4, full-grown larva; 5, pupa: enlarged. After Kerschbaumer.

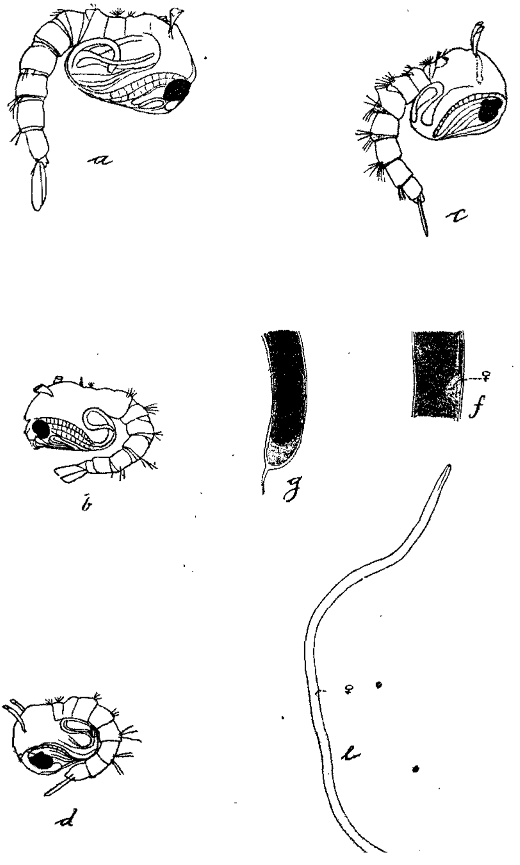
Duration of Larval Life.

This depends upon the conditions of larval existence. The very short period of one week has been reported by Howard (1900, p. 26), but this is possible only in the hottest summer weather and with superabundant nourishment. A fair average, under ordinary conditions, would be about two weeks. Larvæ of *Culex pungens*, reared from the egg in the laboratory and insufficiently nourished during the greater part of their existence, pupated at the end of seventeen days to three weeks, and then at a stage of growth indicated as a half-grown larva in Figure 12. The little pupæ (13 *c*) naturally produced dwarfish adults, and there were twice as many males as females.

The very slow growth of *Anopheles* larvæ under laboratory conditions has been a serious hindrance in rearing them. Usually only the full-grown and nearly full-grown larvæ brought to the laboratory lived to pupate. One-third to one-half-grown larvæ (three to four millimeters long) can be carried through only by constant care. In order to obtain adults in large numbers, it is, therefore, necessary to collect as many advanced larvæ and pupæ as possible.

Duration of Adult Life.

It is often asked, "How long does a mosquito live?"—a question to which a satisfactory answer cannot be given. We know they may and do live a long time under certain conditions. For instance, hibernating mosquitoes live through the winter—even the long Arctic winter. In the tropics they live through the dry season, when breeding is impossible. In captivity they have been known, exceptionally, to live two months; but mosquitoes in confinement are not under normal conditions. It is possible that our summer mosquitoes live longer than the usual lease of life of our captives, which I have found not much to exceed one month for *Culex pungens* and *Anopheles punctipennis*. On the other hand, the usual free life may be briefer. As already stated, my captive mosquitoes have never laid their eggs. It is quite probable the females are not impregnated in captivity, although I have constantly kept males and females together. When an insect has laid its eggs its mission is ended, and it soon dies. If anything prevents or defers egg-laying, then the female may live on. If the males, for any reason, fail to perform their function, they, also, may greatly exceed their usual term of life.


a
c
b
g
f
d
e

All mosquitoes upon which I have based longevity observations have been reared from the larva or pupa. They have been kept in cylindrical, gallon, battery jars. The mouth of the jar is closed with mosquito-bar, held in place by a rubber band. The jar is always kept supplied with water, sometimes also with earth, in which grass or other plants are rooted (although this plan was found objectionable, and was discontinued), and usually with two or three sprigs of "wandering jew" (*Tradescantia*). Ripe fruit, particularly bananas and pears, was used as food, and the female *Anopheles* were allowed to bite at intervals of three or four days. Under these conditions *Culex pungens* have been kept for forty days and *Anopheles punctipennis* for about a month, when the experiment had to be brought to a close. Only a few out of a considerable number have lived so long. The objection may be raised that mosquitoes born so late in the season (August 9th to 19th) may belong to a hibernation brood, which would account alike for their comparatively long life in captivity, and also for their failure to lay eggs. This, however, was not the case, for all, both males and females, fed freely on the fruit, and the female *Anopheles* bit eagerly, even after the middle of September. No conclusions could be drawn from the failure of the later broods of *Culex pungens* to bite, because they had refused to do so throughout the season. Furthermore, a considerable number of females were dissected, and were found to have fully-developed eggs in their ovaries.

Examination of considerable numbers of *Culex* and *Anopheles* from the Boston Parental School, during October and November, 1901, revealed only empty stomachs and undeveloped ovaries. These mosquitoes were all captured indoors, most of them in sleeping-rooms, where they had had every opportunity to bite. It is evident that they had not come indoors to get a meal of blood, but to find hibernation quarters. They were, therefore, the "hibernation brood," which is always the last brood of the season.

The long lease of life of some of the males was a surprise, in view of the reiterated statements of writers to the effect that the males are short lived. A few records are given.

Explanation of Fig. 18.

a, large pupa of *Anopheles punctipennis*, about the maximum size; *b*, very small pupa of same from an undersized larva; both enlarged 9 diameters; *c*, unusually large pupa of *Culex pungens*; *d*, same from an undersized larva reared in the laboratory; both show the small black larval eye adjacent to the large compound eye, and are enlarged 9 diameters. All the above form camera lucida drawings; *e*, thread worm, parasitic in body cavity of *Anopheles* larva from Delair; ♀ enlarged 12.5 times; *f*, vaginal region of ♀, enlarged 68 times; *g*, caudal extremity of same, enlarged 68 times; in figures *f* and *g* the small round bodies are ova. Original by H. P. Johnson.

Culex pungens.—Pupæ from waterbucket in basement. August 7th, pupæ put in battery-jar, provided with earth, water and living plants:

Aug.	16...............	4 males, living.
"	26...............	3 " "
"	28...............	2 " "
Sept.	2...............	1 male, 8 females.
"	5	1 "
"	6.... ....No	"
"	18...............	5 females, which were cholroformed, and record closed.

Longest life of a male, twenty-seven days; of females, forty -|- days. August 9th is taken as date of hatching from the pupa.

Psorophora ciliata.—Received as larvæ from Mr. William P. Seal, Delair. Pupæ put in battery-jar, arranged as for *Culex pungens.*

Aug.	2. (9:30 A. M.)...........	1 male, just emerging from pupa.
"	4.............................	2 males, 2 females.
"	13.............................	1 male (dying), 2 females.
"	17.............................	2 females.
"	19.............................	1 female.
"	20.............................	Extinct.

Longest life of a male, nine days; longest life of a female, sixteen days.

Anopheles punctipennis.—(First colony).

Aug.	8.	Started with 19 pupæ.
"	9.	(12 M.) 1 female, 5 males.
"	9.	(6 P. M.) 1 female, 7 males.
"	11.	(10:40 A. M.) 4 females, 7 males.
"	12.	Two dead males found.
"	14.	4 females and 5 or 6 males still alive.
"	14.	12 pupæ added. Two hatched to-day.
"	22.	Males dying off.
"	25.	3 or 4 males left.
"	25.	3 pupæ added.
"	27.	2 pupæ added.
Sept.	3.	3 females, 2 males (from pupæ added August 25th and 27th).

(Record closed.)

Anopheles punctipennis.—(Second colony).

Aug	13.	Many pupæ placed in battery-jar.			
"	17.	12 pupæ placed in same battery-jar.			
"	18.	12 pupæ still unhatched.			
"	19	3 pupæ still unhatched.			
"	28.	Several males still alive.			
Sept.	2	5 males, 8 females.			
"	4.	5	"	8	"
"	8.	3	"	8	"
"	10.	3	"	5	"
"	12	3	"	4	"
"	13.	3	"	3	"
"	15.	3	"	3	"
"	17.	3	"	2	"

(Record closed.)

The last record is the most remarkable, for the males actually held their own better than the females. The conditions for both sexes were precisely the same, except that the females were allowed to bite at intervals, which the males always refused to do.

Proportion of the Sexes, Apparently Determined by Degrees of Larval Development.

With *Anopheles* it was a matter of practical importance to separate the large pupæ (*13 a*) from the small ones (*13 b*). In order to obtain a stock of large, vigorous females for inoculation experiments, it was necessary to get large pupæ from which to rear them. Most of these were pupæ collected out-of-doors or pupæ from very large, full-grown larvæ recently brought in. Of course, large size presupposes ample food, abundant sunshine and possibly other favorable conditions not always realized indoors. Pupæ coming from larvæ that had been long in the laboratory were generally small.

Both from the scientific and the practical point of view much interest inheres in the determination of sex by the external conditions of life. Nowhere have experiments more clearly shown that the proportion of the sexes may be controlled than among insects. Mrs. Mary Treat, of Vineland, N. J., has recently published (1898) an account of a most interesting series of experiments with the butterfly (*Papilio asterias*). When the caterpillars were underfed a great preponderance of males was obtained, almost, but never entirely, to the

exclusion of females. Landois obtained in the same way similar results with the caterpillars of *Vanessa urticæ.*

My results with mosquitoes, while too scanty to be conclusive, are, perhaps, worth recording.

Twenty-three large pupæ of *A. punctipennis* gave fifteen females and six males. Two pupæ died. Therefore, 71.43 per cent. were females and 28.57 per cent. were males. Twenty-three small pupæ of *A. punctipennis* yielded three females (20 per cent.) and twelve males (80 per cent.); eight died either as pupæ or in the act of hatching. There is often a high rate of mortality among the small pupæ.

A single experiment was made with *Culex pungens.* Larvæ hatched from the egg on August 4th, and 5th were kept in a dish in the laboratory, without sufficient food, and the first pupa was found August 23d, which must have come from a larva not more than half-grown. Four more pupæ appeared two days later; and, to stimulate pupation, the larvæ were now liberally fed. By the 29th about twenty pupæ had appeared; these had all been placed in a battery-jar, and yielded twelve males (66 2-3 per cent.) and six females (33 1-3 per cent.).

Food of Larvæ.

A good many experiments were made to determine the best food for rearing the larvæ of *Anopheles,* and, incidentally, a few with *Culex pungens.* The conclusion reached from these experiments and from microscopic examination of the contents of the alimentary canals of the larvæ was that the minutest algæ, notably *Protococcus, Scenedesmus, Raphidium, Cosmarium,** and no doubt a variety of other Desmids and Diatoms, form the chief food of the larvæ. Bits of filamentous algæ (Spirogyra, etc.) are also swallowed; but animal food was not detected. The larvæ browse on decaying vegetation, eating off not only minute vegetal growths (Bacteria, etc.) that cover it, but the cellular substance of the leaves and stems as well. Epidermal cells of leaves have been found in the stomachs of larvæ.

A good way to promote the growth of *Culex pungens* larvæ is to put grass in the water. In decaying it promotes the development of bacteria, and, later, of microscopic algæ. It is evident, from the prompt growth of the larvæ, that the rotting grass, stems and leaves, and possibly the bacteria, serve as food. As already noted, larvæ of

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* I am indebted to Mr. Horatio N. Parker for the determination of these.

C. pungens thrive in very foul water, even that contaminated by sewage. *Anopheles* larvæ I have never found in such water.

The fact that the great bulk of the contents of the stomachs of both *Anopheles* and *Culex* larvæ is *Protococcus*, indicates this as a staple article of diet. I have not observed much selection of the particles brought to the mouth by the vortex created by the maxillary brushes, and there is nothing to indicate such selection in the contents of the stomach. *Anopheles*, being largely a surface-feeder, draws to its mouth all sorts of floating particles. On dusty days a great deal of inorganic matter falls on the water, and these wholly innutritious particles find their way to the stomach in sufficient numbers to make its contents decidedly "gritty." The view expressed by Howard (1900, p. 38), that the specific gravity of the *Anopheles* larva is materially reduced because it feeds upon floating particles, and therefore "it supports this horizontal position just beneath the surface film with comparative ease, and, in fact, without effort, the tension of the surface film itself being hardly needed to hold it," is not sustained by this observation. The large amount of mineral matter which the *Anopheles* larva occasionally takes in certainly does tend to increase its specific gravity, and yet it remains at the surface without the least effort. I have frequently seen the larvæ feeding at the bottom, and lying there inert, without the slightest visible movement or apparent effort. It is evident, then, that their specific gravity, like that of most animals, is actually greater than that of water, and they remain at the surface in a horizontal position because held there by surface tension. Not merely the cephalic and caudal extremities, as represented by Howard (1900, Figure 14; 1901, Figure 19), break the surface film, but, as a rule, the entire length. The position shown by Howard, with only head and caudal end breaking the surface, is sometimes assumed, but it not usual or typical.

Biting Habits.

These particular "habits" of mosquitoes may be considered to require no remark. Most people would regard them as well known already. Still, there are misconceptions regarding this pernicious practice of the female mosquito.

Males, apparently, never bite. Not that they are averse to blood, for Berkeley (1902, p. 29) has found that they will feed upon it if it is offered to them on a swab. Many times I have tried to induce

male *Anopheles* in confinement to bite, but have never succeeded Female *Anopheles,* a certain number of days after coming from th pupæ, bite quite freely, even during the daytime, which is contrar to their habits when free. In no instance have I been able to induc *Anopheles* to bite until at least six days after leaving the pupa During this interval, however, they frequently suck the juice of rip fruit.

It is commonly believed that a mosquito that has gorged itself wil not bite again; but recent experimental studies have exploded thi idea. Indeed, the transmission of both malaria and yellow fever de pends on their biting at least twice. I find that *Anopheles* that hav bit once are, if anything, more likely to bite again. They even bit sometimes as frequently as every other day, when they have not full digested the previous meal. A female *punctipennis* that was kep isolated bit at 9:30 A. M. September 3d; at 10:50 A. M. Septembe 6th; at 11 A. M. September 8th, and at 10:30 A. M. September 10th After that she was evidently satisfied, for I could not induce her to bite again.

Why female mosquitoes bite is not certainly known. It is some times thought that they need the blood in order to mature their eggs but it has never been satisfactorily shown that they cannot lay afte partaking of a simple diet of the juices of plants. Wherever they swarm in uninhabited regions this must be the case. The fact tha both *Anopheles* and *Culex* of the hibernation brood do not partak of blood in the autumn before going into winter quarters (when thei ova are to remain undeveloped for months), but are most blood thirsty after they emerge in spring (*Anopheles* at this time, as I hav observed, biting even in the daytime), seemingly indicates a correla tion between a meal of blood and the rapid maturing of the eggs.

Parasites.

Beautiful clusters of Vorticellids are frequently to be seen on the thorax, abdomen, and even on the head of the larvæ of *Culex pungens.* They may be so abundant as to give the thorax, especially, a whitish, gelatinous appearance to the naked eye. It is unlikely that these Vorticellids do the larva any harm, as the larva simply affords them an attachment and transportation—possibly, food also—brought by the vortex which it creates in the water.

The only internal parasite found was a small Nematode, or thread-worm (Figure 13 *e*), in the larvæ of *Anopheles*. It lives in the body cavity, and is probably not very common. Six were obtained during the summer, all from larvæ sent to me by Mr. William P. Seal, of Delair. Only one was found by dissection, the others were in the bottom of a dish containing a newly-received lot of the larvæ, many of which were dead. The Nematodes were alive, however, and had very likely crawled out of the dead and partly-disintegrated larvæ. The Nematode is about twice as long, on the average, as the larva it inhabits, the specimens represented in Figure 13 *e* measuring 9.17 mm. in length and .16 mm. in greatest diameter, tapering slightly towards anterior and posterior ends. The opening of the vagina (Figure 13 *f*, female) is slightly nearer the head than the posterior extremity. The anus has not been found. The caudal extremity (Figure 13 *g*) is filiform, and tapers to a fine point; its length is not quite equal to the diameter of the posterior region. The entire worm, except a limited region at the posterior extremity, is packed with very minute ova, which completely conceal the intestine. No oral papillæ have been detected.

More abundant material and other stages in its development are necessary to determine the relationships of this interesting parasite. It is possible that it is sometimes numerous enough and sufficiently injurious to serve as a check on the increase of *Anopheles*.

The Transmission of Malaria.

There is a wide-spread misapprehension regarding the way in which malaria is transmitted by mosquitoes. Many who unhesitatingly accept this view are unable to explain upon what foundation it rests, or why it has so quickly won the acceptance of biologists the world over. Many, even of the medical profession, attach little or no importance to the really great differences in the modes of existence of the various disease germs. Hence, it is not surprising that they should regard the malarial organism as a germ of the same sort as bacteria, endowed with the well-known power of most bacteria to live outside the animal body and withstand cold, heat, dryness and other adverse conditions. If this were so, modes of transmission other than that by mosquitoes would require the most careful consideration. No reputable pathologist or bacteriologist would ventnre to assert that

one might not contract malaria as one contracts typhoid or diphtheria or small-pox. The simpler the life history of a pathogenic organism, the greater the variety of conditions under which it can lead an active existence. As compared with bacteria, the life history of the malarial organism is exceedingly complex; accordingly, we find its conditions of existence rigorously restricted. So far as known, not one of the whole great group of the Sporozoa (literally, spore-producing animals), to which the malaria organism belongs, can lead an active existence outside its appropriate host. Without exception, they are obligatory parasites. Probably all of them pass at least a portion of their cycle within the very cells of their host. It is not surprising, therefore, that none of the Sporozoa have been found to lead a saprophytic existence; that not one has been cultivated outside its host. With the bacteria, on the contrary, it is the exception that they cannot be reared on nutrient media.

The host species of any Sporozoon are always few and closely related; frequently there is but one. Again, within the body of the host these fastidious parasites elect only cells of a certain tissue, and often even that tissue as it occurs in some particular organ. Thus, the entire order Hæmatozoa, to which the malarial organism belongs, live in the red blood corpuscles, but in no other part of the vertebrate body. Here they are completely shut in from the outer world, to which they have no direct access. The blood-sucking habit of the mosquito affords them an exit—first, to the mosquito's body, where they pass through a cycle different from that in the blood, and then, by the agency of the mosquito, back to the circulation of man, beast or bird, according to the special form of malaria.

The Hæmatozoa differ from the rest of the Sporozoa, inasmuch as they live in two hosts, vertebrate and mosquito or some other blood-sucking parasite. In all forms of human malaria yet investigated the carrier host is a mosquito of the genus *Anopheles*. This reveals the highly-specialized nature of their parasitism. *Culex*, so nearly related to *Anopheles*, so like it in all its structure, physiology and habits, cannot become infected, so far as known, with any form of human malaria. On the other hand, the malaria of birds, which differs slightly from human malaria, cannot be transmitted by *Anopheles*, but only by *Culex*. Yellow fever, again, has been experimentally shown to be transmitted by still a third form of mosquito, *Stegomyia fasciata*. For the germ of cattle fever (known in this country as Texas cattle fever) no species of mosquito, nor even any true insect,

serves as the transmitting host, but a blood-sucking parasite of the Arachnid group, the cattle-tick (*Boophilus bovis*) (Smith and Kilborne, 1893). Indeed, there is strong circumstantial evidence that a rare and local human hæmatozoic disease, the "spotted fever" of the Rocky Mountain region, is transmitted by the bite of a tick (Wilson and Chowning, 1902).

Can any species of Sporozoon pass from host to host without an animal carrier? The answer to this question concerns us much. As soon as it is demonstrated that even one form of the disease-producing Sporozoan can pass from one vertebrate to another, we naturally inquire whether this may not be the case sometimes with the malarial parasite also. The answer is, emphatically, no! Notwithstanding there are numerous Sporozoa which pass from one host to enter another of the same species, with an intermediate sojourn in the outer world, this passage is made in the form of encysted spores. Encystment is absolutely necessary to protect these delicate organisms from dessiccation. Since no encystment occurs with the malaria germ, or with any of the known Hæmatozoa, we are justified in concluding that direct transmission is impossible for them. Like the seed of a plant, the animal spore must reach a suitable soil before it can germinate. The only suitable soil is the body of its appropriate host. To give a specific instance: There is a disease of rabbits known as Coccidiosis, caused by the Sporozoon *Coccidium oviforme,* which invades, in vast numbers, the epithelial cells of the gall ducts and small intestine. *Coccidium oviforme* has a life history almost identical with that of the malarial parasite, but with the important difference that both the sexual and asexual cycle are passed in the same host. The rabbit is, so to speak, both the intermediate and the definitive host,* and the Coccidium has simply to pass from rabbit to rabbit. This it does in the most direct way possible, passing out of the body in the form of spores with the fæces, and then, still in the spore form, is taken with the food into the digestive tract of another rabbit, which it infects in turn. Were such a simple mode of direct infection possible for the malarial para-

* The use of the terms "intermediate" and "definitive" as applied to hosts has heretofore been accurate and clear to parasitology, but unfortunately the mosquito-malaria-theory has introduced some confusion. The definitive host is invariably the one in which the parasite attains sexual maturity, and in which sexual reproduction occurs. All reproductive processes in the intermediate host are asexual. Hence man, not the mosquito, is the intermediate host of the malaria parasite, for the sporulation in the blood is asexual, while the phases in the mosquito are sexual.

site, we may be well assured it would be followed; for nature does not adopt roundabout methods when direct ones will serve her ends. To the parasitologist, therefore, the fact that experiments have shown beyond a doubt that malaria is transmitted by mosquitoes is sufficient proof that this is the only means of transmission.

We may, accordingly, dismiss once and for all the time-honored but never-proven doctrine that malaria germs lurk in damp soil or float in the miasma of swamps, ready to infect mankind whenever the soil is disturbed or the swamp air is breathed. That we may get malaria from swamps and in consequence of breaking the soil cannot be denied; however, we get it, not directly, but because these conditions favor the breeding of *Anopheles.*

Although the life history of the malarial parasite is a subject to which I can add nothing new, and one already much written about, it seems not superfluous, in view of the general failure to comprehend its true import, to state it quite fully, in language as untechnical as is consistent with accuracy.

At the outset it is necessary to define just what is meant by "malaria," for many and diverse ailments masquerade under this convenient guise. Many physicians diagnose as "malaria" a general malaise characterized by a slight fever, which is relieved by administering quinine. Again, there may be a "chill" as well as a fever. Even this does not prove a case of malaria, which can be diagnosed with certainty only from the blood. Unless, after reasonably diligent search, the malarial germ ("plasmodium" or "amœbula") is found in the blood, it is safe to conclude the disease is not true malaria, no matter what the symptoms. The malarial paroxysm or "chill" is undoubtedly the most reliable clinical symptom, but is not infallible.

If freshly-drawn malarious blood is kept at body temperature, and protected from the atmosphere, the plasmodia in the corpuscles may be seen to exhibit active streaming or amœboid movements; hence, the names "Plasmodium" and "Amœbula" are very appropriate. The plasmodium remains constantly within the corpuscle and feeds upon it. The hæmoglobin of the corpuscle is the source of the characteristic pigment seen in the plasmodium. Eventually the corpuscle is destroyed. The application of a suitable dye to a dried blood-smear on a glass slide or cover-glass, stains, not only the plasmodium in its entirety, but also its nucleus, thus demonstrating that the malarial organism is a cell. It is, in fact, a unicellular animal, a protozoon.

By far the commonest type of malaria in this latitude is the tertian, in which the paroxysm comes every other day. The quartan, in which the chill recurs at intervals of seventy-two hours, is comparatively rare; while the æstivo-autumnal, or tropical, fever with us is properly an exotic from the tropics or Southern Europe; but, according to Dr. Berkeley, it has obtained a foothold in New York City, where small epidemics of it occur every summer. In this type of malaria the chills come at irregular intervals.

Parasitologists now recognize that each of these three types of malaria is caused by a different and distinct species of malarial parasite, distinguishable by well-marked morphological characters. Thus, tertian fevers are produced by *Plasmodium vivax;* quartan by *Plasmodium malariæ*, and æstivo-autumnal by *Laverania malariæ*. Some have thought it possible to distinguish a fourth type, the quotidian, characterized by a daily paroxysm. The now generally-accepted explanation of this "type" is that it is simply the result of a double infection of tertian. It is possible, also, to have a double infection of quartan or of tertian and quartan, so that recurrence of the paroxysm may come sometimes every day, or even oftener, and, again, on alternate days.

In every form of malaria the chill marks an important epoch in the life history of the parasite. At this time "sporulation" is taking place—that is to say, the plasmodia, having attained the limit of their individual growth, and having used up all the nourishment afforded by the corpuscle, reproduce asexually. The nucleus divides into several daughter-nuclei, and each of these gathers to itself its due quota of the living substance, the protoplasm, of the mother-cell. The enclosing membrane of the used-up corpuscle now ruptures, and the spores (known technically as the "schizospores" or "merozoits") escape into the blood serum, and thence invade other corpuscles. In doing this they disturb the temperature equilibrium of the body, and the "chill" results. The giving of quinine is most effective at the onset of the chill, because, no doubt, the free spores in the blood are more exposed to the poisoning action of quinine than are the plasmodia in the corpuscles.

If the fever is left to take its course, more and more corpuscles are invaded and destroyed; the patient constantly gets worse. Whether a condition of effective resistance is attainable—in other words, whether we may at length become immune—is not known, because

of the well-nigh universal use of quinine in all civilized countries, thus breaking up the fever before the body has time to develop any resistant powers it may possess. A fact of great significance in connection with this matter is the observation of Koch that the well-known immunity of the Negro race is not natural, but acquired. All Negro children in the malarious regions of Africa have malaria, and as they grow up gradually become immune. Natural immunity among Caucasians is extremely rare; but instances of it have been known in Italy.

The malarial organism was discovered in the human blood by the French army surgeon, Laveran, in 1880. Although his discovery obtained little acceptance for a decade, it has since become universally recognized as the cause of malaria, and has everywhere served as a valuable means of diagnosis. For years the presence of the plasmodium in the blood corpuscle was a standing enigma. It was not difficult to follow it through its apparently simple phases from the spore to the full-grown plasmodium, thence to the spore again. These changes take place with clock-like regularity. But how did the first germs get into the blood, and how can a parasite so located infect new individuals?

Light began to dawn on this knotty problem with the discovery, in 1897, by MacCallum, at Johns Hopkins University, of a new and entirely unexpected phase. Incredible as it may seem, these tiny organisms, unicellular though they are, have a sexual reproduction. The purely asexual, sporulating process in the blood may go on for a long period, but not indefinitely. Sooner or later some of the plasmodia assume an appearance different from the rest. The difference is but slight in tertian and quartan fevers, but in the æstivo-autumnal it is striking. In this form of malaria a large number of the plasmodia assume a semi-lumar form and are known as the "crescents." A general name now applied to these bodies is "gamete" or "gametocyte." On drawing a little blood and closely watching the gametes under the microscope the observation originally made by MacCallum may be repeated. Some of the gametes, distinguishable by slightly-larger size, will suddenly be seen to give birth to several actively, lashing, thread-like bodies, known as the flagella or microgametes. These swim actively through the blood serum, and finally unite with other gametes, which have remained inert, producing no flagellated bodies. The union of these two bodies—the inert macrogamete and

the tiny, active microgamete—constitutes the process of fecundation. It is essentially the union of the male element (spermatozoon) and the female element (egg or ovum), which everywhere inaugurates the development of a new being. Only, in the case of the malarial organism, we have to do with a unicellular parasite, and one perfectly adjusted to a very special mode of existence. It was soon ascertained that "exflagellation" (and, consequently, fertilization) never occurs until the blood has been drawn. The cycle which it inaugurates must, therefore, be passed somewhere outside the human body. But where and how?

Two years before MacCallum's discovery an English army surgeon stationed in India, Major Ronald Ross, following a suggestion of Manson, who had then recently discovered that human filariasis is transmitted by mosquitoes, began experimenting with mosquitoes of the genus *Culex*. The mosquitoes were allowed to bite persons suffering with malaria, but with uniformly negative results. The mosquitoes remained sterile. Finally, in 1897, Ross employed "dapple-winged mosquitoes" (*Anopheles*), allowing them to bite a patient whose blood contained the crescents of æstivo-autumnal fever. Four or five days later he found on the stomach of two of the mosquitoes pigmented bodies, evidently parasitic, which he rightly identified as the malarial organism. The matter, however, was not proved. It was not alone necessary that the patient should infect the mosquito; the mosquito, in turn, must infect a human subject. On account of the inevitable difficulties of experimenting with human beings, Ross employed birds, which have their own types of malaria, slightly different from human malaria. The mosquitoes used were of the genus *Culex*—the very species that had given only negative results with human malaria. The experiments were entirely successful. From biting malarious birds the mosquitoes became infected with the malaria. The germs could be followed in their development in the mosquito step by step until the cycle was completed. Then, multiplied ten thousandfold, in the form of exceedingly minute sickle-shaped bodies (known as "blasts" or "sporozoits"), they gathered in the salivary glands, ready to enter, with the poisonous saliva, the blood of any bird that might be bitten. Healthy birds bitten by mosquitoes having the malaria germs in this stage of development in five to nine days were found to have the plasmodium in their blood.

While Ross was experimenting in India, a number of Italian in-

vestigators, prominent among whom were Grassi, Dionesi, Bignami and Bastianelli, had been busy with the same problem, and the results of their extended and painstaking researches showed, beyond a doubt, that *Anopheles* was the carrier and the intermediate host of the three best-known forms of human malaria, and that *Culex* played the same part for bird malaria. The "mosquito-malaria theory" was now no longer a thought, but an established fact. It only remained to work out details and conduct experiments of a less technical, but more comprehensible and more convenient, sort for those not versed in the intricate life histories of animal parasites.

What manner of development is it that takes place in the mosquito? The figures on Plate 14 (modified from Grassi, 101) will help to make it clear. Starting at 1 with the organism in the form of a sporozoit, which invades the human blood with the help of an infected *Anopheles*, we see, first, the simple, asexual cycle, which produces an attack of malaria. Each of the many sporozoits that *Anopheles* injects, with poison, into the blood seeks a red corpuscle and passes inside of it. It grows at the expense of the corpuscle, becoming the familiar plasmodium, and at full maturity divides into a small number of spores, which are scattered in the blood serum and pron[illegible] fresh corpuscles. Every time this occurs there is a "chill." [illegible] gametes appear, at first a few, then numerously. If the pa[illegible] bitten by *Anopheles*, the fertilization (Figure 14, 6) tal[illegible] the mosquito's stomach and the sexual cycle begins. As the[illegible] we get a little, worm-like body, the ookinet or vermicule, w[illegible] its way into the wall of the mosquito's stomach. The stag[illegible] in Figure 8 is passed in the wall of the stomach. The subsequent stages, characterized by very rapid growth, occur, apparently, on the outside (*i. e.*, the peritoneal surface) of the stomach, but, actually, just under the extremely thin, muscular and elastic layer, which is very distensible and stretches to accommodate the growth of the parasite. These large bodies soon become visible on the stomach of an infected mosquito (Figure 15,* four and one-half days after infection) with a low power of the microscope. Still, the growth continues (Figure 14, 11), and now we find there has been a division of the nucleus, and the more the amphiont (as it is called) increases in size, the more numerous become the nuclei. Each nucleus gathers to itself a stellate mass of protoplasm.

* Dr. Berkeley's Figure 49.

Then, within this mass still further divisions of the nucleus take place, the now minute daughter-nuclei crowding to the surface of the irregular masses of protoplasm (Figure 14, 15). Each tiny nucleus is soon the centre of a rod-shaped body, and there are several thousands of these rod-like bodies (the sporozoits) in the enormously-enlarged Amphiont. Large groups of them lie parallel to each other,

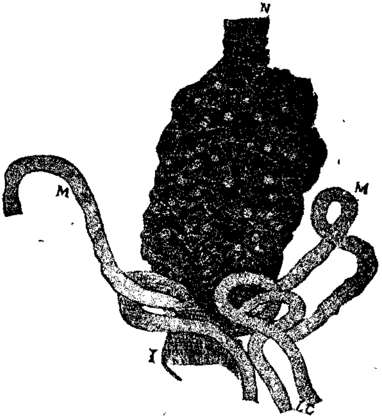

Fig. 15.

Stomach of *Anopheles maculipennis*, showing malarial *Zygotes* or *Amphionts* 4½ days old. The rounded, pygmented zygotes lie in the meshes of the muscular fibres. *N*, neck of stomach: *M* malpighian tubules; *I*, ileum. From Berkeley's Lab. Work with Mosquitoes.

producing the characteristic striated appearance (Figure 14, 17). The capsule bursts and the 10,000 or more sporozoits are set free in the mosquito's body cavity. Owing to some attraction of unknown nature, but presumably chemotaxis, they gather in the large, vacuolated cells of the salivary glands (Figure 16). Thence, they are injected, with the secretion, into the first person the *Anopheles* bites, and after a short period of incubation that individual comes down with malaria.

The same mosquito can, and no doubt often does, infect more than one indivudal. The length of time the sporozoits retain their vitality in the mosquito is not known. Observations by Grassi indicate that the sporozoits do not live through the winter in hibernating mosquitoes; and a study of mosquitoes by the writer (see page 575) in the autumn of 1901 would strongly indicate that hibernating *Anopheles* do not bite at all before going into winter quarters. But when

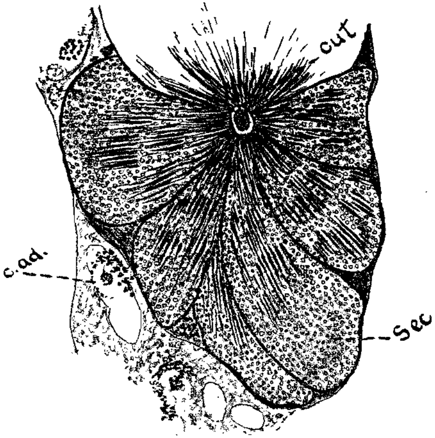

Fig. 16.
Section through a salivary gland of *Anopheles maculipennis*, showing the location of the sporozoits. Redrawn from Grassi.

they emerge in the early spring, such is their eagerness for blood, that they bite even in the daytime.

There is every reason to believe that malaria is carried over from one season to the next in the blood of man, and not in the mosquito. The cases of malaria which develop in winter are relapses of previous attacks; or, in rare instances, an infected *Anopheles* remains active in a warm room and bites at night, thus producing a new case of malaria.

There is good reason to believe that if every case of malaria could be completely cured and all plasmodia eradicated before the advent of another season, endemic malaria in temperate climes would become extinct in a single year.

It has been said on a previous page that the proof afforded by the development of the malarial organism in *Anopheles* and the infection of well persons by infected *Anopheles,* although absolutely convincing to the biologist, is not so to the lay mind. It was necessary that proof of another sort should be obtained, and this was done in a way as interesting as it was convincing.

In the Plain of Capaccio, Italy, Grassi (1901, p. 216), in 1900, made an experiment on a large scale. Ten cottages at the railway station of San Nicolo, Varco and Albanella were made mosquito-proof by carefully screening doors and windows. The doorways were provided with double screen doors. It may be stated, by the way, that the netting was of considerably smaller mesh than customary in this country. Of the 104 persons living in these ten cottages, all but eleven had previously lived in malarious regions; a majority had suffered from it during the previous season. The malarious season began each year about June 13th, according to the testimony of inhabitants of the district. This was confirmed by actual examination of a large number of *Anopheles.* None were found with sporozoits in their salivary (*i. e.,* poison) glands until June 14th. As early as March 25th vigorous efforts were begun to cure all who had malaria in their blood, the result of infection during the previous season. Grassi says: "The spectacle which these people presented before we began our treatment was the saddest imaginable; and those families who had lived in the place during the entire malarial season of the preceding year most strongly excited our sympathy." The "reconstitutions treatment" was not entirely successful, because begun too late. Even in June there were seven relapses of persons who had had malaria the previous season.

During the entire malarial season, from June 25th (when the first new case appeared in that region) till October 15th, the people in the protected houses enjoyed good health, notwithstanding they took no quinine. There were very few cases of sickness other than malaria, and five light cases of malaria, which soon disappeared, and all of which Grassi regarded as relapsing cases.

Of the 415 persons living in the immediate vicinity of the protected houses, every one had malaria during the season.

Another experiment made in the Roman Campagna—a district of most unsavory reputation for its terrible fevers—has been widely published.

In the latter part of the summer of 1900 two London doctors, Sambon and Low, erected a wooden cottage in the Campagna, near Ostia. The place selected was known to be one of the most malarious in the whole Campagna. The house was built so as to leave no chinks or crevices, and windows and doors were thoroughly screened. Drs. Sambon and Low lived here throughout the malaria season. They abstained from quinine, and took no precautions, except to be invariably within doors at sunset and not to go out until daylight. During the day they investigated the cases of human and cattle malaria in the neighboring villages and indoors conducted laboratory work. In short, they lived as people generally live, but were invariably indoors before the flight time of *Anopheles*. With the rains began the most dangerous part of the season. The natives of the region, having malaria in their systems, were pretty sure to come down with an attack at this time. The experimenters frequently went out in the rain and were wet through; but neither of them contracted malaria. The idea has everywhere prevailed that the night air is dangerous; but the well-screened windows of the cottage were left open night and day.

The objection may be made that *Anopheles* occur in many places where there is no malaria. This is perfectly true; but it does not prove that *Anopheles* is not the carrier of the disease. It only proves that the mosquitoes have had no opportunity to infect themselves by biting a malarious patient. A single person with malaria may start an epidemic in any *Anopheles* infested place.

Both from our knowledge of parasites of the class to which the malaria organism belongs and from the abundant experimental evidence we are justified in the conclusion that malaria is transmitted by mosquitoes of the genus *Anopheles*, and in no other way, save by the purely artificial method of inoculation of malarial blood.

LITERATURE CITED.

N. B.—The year of publication is placed first, and serves as a reference number.

1902. Berkeley, Wm. N. Laboratory Work With Mosquitoes. Pediatrics Laboratory, New York; 112 pp. 61 figures.

1901. Grassi, B. Die Malaria. Zweite Auflage. Gustav Fischer, Jena; 250 pp., 8 plates.

1900. Howard, L. O. Notes on the Mosquitoes of the United States. Bulletin No. 23 (new series) United States Department of Agriculture, Division of Entomology: 70 pp., 22 figures.

1901. Howard, L. O. Mosquitoes: How They Live, How They Carry Disease, How They May be Destroyed. McClure & Company, New York: 241 pp., 50 figures.

1902. Johnson, H. P. A New Sporozoan Parasite of *Anopheles*. Journal of Medical Research, VII., 2, pp. 213–219, 1 plate.

1902. Jordan, E. O. Notes on the Occurrence and Habitat of *Anopheles punctipennis* and *Anopheles maculipennis* in the Valley of the Androscoggin. Journal of Medical Research, VII., 1, pp. 1–24, 1 plate.

1901. Kerschbaumer, Fritz. Malaria, ihr Wesen, ihre Entstehung, und ihre Verhutung. Braumuller, Vienna; 170 pp., 12 plates.

1893. Smith, Theobald, and F. L. Kilburne. Journal of Hygiene and Herald of Health, XLVIII., 5, pp.

1902. Wilson, L. B., and Wm. M. Chowning. The So-called "Spotted Fever" of the Rocky Mountains. The Journal of the American Medical Association, July 19th, 1902; 18 pp.

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